Office of the Secretary of Defense (OSD)
Assistant Secretary of Defense (Research & Engineering)
12.3 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

Introduction

The Assistant Secretary of Defense (Research & Engineering) SBIR Program is sponsoring topics in the following technology focus areas: Energy and Power; Cyber Trust, Resiliency, Agility, and Assuring Missions; Autonomous Systems that Reliably and Safely Accomplish Complex Tasks, in Operational Environments; Innovative Approaches to Flexible Information-Centric Interfaces in Operations; Tools for Engineering Resilient Systems; and Data-to-Decisions.

The Army, Navy and Air Force are participating in the OSD SBIR Program on this solicitation. The service laboratories act as OSD's Agent in the management and execution of the contracts with small businesses.

In order to participate in the OSD SBIR Program, all potential proposers should register on the DoD SBIR Web site at http://www.dodsbir.net/submission as soon as possible. Follow the instructions for electronic submittal of proposals. It is required that all proposers submit their proposal electronically through the DoD SBIR/STTR Proposal Submission Web site at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the SBIR/STTR Help Desk (toll free) at: 1-866-724-7457.

Refer to Section 1.5 of the DoD Program Solicitation for the process of submitting questions on SBIR and Solicitation Topics. During the Pre-release period, proposers have an opportunity to contact topic authors by telephone or e-mail to ask technical questions about specific solicitation topics, however, proposal evaluation is conducted only on the written proposal. Contact during the Pre-release period is considered informal, and will not be factored into the selection for award of contracts. Contact with the topic authors by telephone or e-mail after the Pre-release period is prohibited. To obtain answers to technical questions during the formal Solicitation period, please visit http://www.dodsbir.net/sitis. Refer to the Program Solicitation for the exact dates.

OSD WILL NOT accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal; however, there is a **25-page limit**. File uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit your proposal prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the ASD(R&E) SBIR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the ASD(R&E) SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Proposal Submission

Refer to Sections 3.0 and 6.0 of the DoD Program Solicitation for program requirements and proposal submission. Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the SBIR/STTR Interactive Technical Information System (SITIS).

Proposer Eligibility and Limitations

Each proposer must qualify as a small business for research or research and development purposes and certify to this on the Cover Sheet of the proposal. In addition, a minimum of two-thirds of the research and/or analytical work in Phase I must be carried out by the proposing firm. For Phase II, a minimum of one-half (50%) of the research and/or analytical work must be performed by the proposing firm. The percentage of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their DoD contracting officer during contract negotiations. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization. For both Phase I and Phase II, all research or research and development work must be performed by the small business concern and its subcontractors in the United States. Deviations from the requirements in this paragraph must be approved in writing by the contracting officer (during contract negotiations).

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 15 U.S.C. § 631.

Definition of a Small Business

A small business concern is one that, at the time of award of Phase I and Phase II, meets all of the criteria established by the Small Business Administration which are published in 13 C.F.R § 121.701-705, repeated here for clarity. A small business concern is one that, at the time of award of Phase I and Phase II, meets all of the following criteria:

a. Is independently owned and operated, is not dominant in the field of operation in which it is proposing, has a place of business in the United States and operates primarily within the United States or makes a significant contribution to the US economy, and is organized for profit.

b. Is (a) at least 51% owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States, or (b) it must be a for-profit business concern that is at least 51% owned and controlled by another for-profit business concern that is at least 51% owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States.

c. Has, including its affiliates, an average number of employees for the preceding 12 months not exceeding 500, and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns are generally considered to be affiliates of one another when either directly or indirectly,

(a) one concern controls or has the power to control the other; or (b) a third-party/parties controls or has the power to control both.

Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR 121.103. The term "number of employees" is defined in 13 CFR 121.106.

A business concern may be in the form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust, or cooperative. Further information may be obtained at http://sba.gov/size or by contacting the Small Business Administration's Government Contracting Area Office or Office of Size Standards.

Description of the OSD SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $150,000. OSD plans to fund three Phase I contracts, on average, and down-select to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals are evaluated using the Phase I evaluation criteria, in accordance with Section 4.2 of the DoD Program Solicitation. Proposals should concentrate on research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3 of the DoD Program Solicitation.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover two to five person-years of effort over a period generally not to exceed 24 months (subject to negotiation), with a dollar value up to $1,000,000. Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

For Phase II, no separate solicitation will be issued. Only firms awarded Phase I contracts, and that have successfully completed their Phase I efforts, may be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released approximately at the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in Section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 4.3 of this solicitation.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the Component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

Phase II Plus Program

The OSD SBIR Program has a Phase II Plus Program, which provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II Plus allows for an existing Phase II OSD SBIR contract to be extended for up to one year per Phase II Plus application, to perform additional research and development. Phase II Plus matching funds will be provided on a one-for-one basis up to a maximum $500,000 of SBIR funds. All Phase II Plus awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Plus contract modification. The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program must be obligated on the OSD Phase II contract as a modification just prior to or concurrent with the OSD SBIR funds. Private sector funds must be deemed an "outside investor" which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

Fast Track Policy

The Fast Track provisions in Section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial (both Defense and Private Sector) products. Proposers are encouraged to obtain a contingent commitment for follow-on funding prior to Phase II where it is felt that the research and development has commercialization potential in either a Defense system or the private sector. Proposers who feel that their research and development has the potential to meet Defense system objectives or private sector market needs are encouraged to obtain either non-SBIR DoD follow-on funding or non-federal follow-on funding, for Phase III to pursue commercialization development. The commitment should be obtained during the course of Phase I performance, or early in the Phase II performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify funding to pursue further development for commercial (either Defense related or private sector) purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation and awarded contract.

The following pages contain a summary of the technology focus areas, followed by the topics within each focus area.

Energy and Power Technology Focus Area

Technological advances in electric power generation, distribution and use are enabling transformational military capabilities. Advanced power generating technologies enable significant improvements in platform flexibility, survivability, lethality and effectiveness. The Army's transformation challenge is to develop a smaller, lighter, and faster force, utilizing hybrid electric drive, electric armament and protection, and a reduced logistical footprint. The Navy is developing future ship concepts that integrate electric power into a next-generation architecture which enables directed energy weapons, electromagnetic launchers and recovery, new sensors, as well as supporting significant fuel, maintenance, and manning reductions. The Air Force needs electric power to replace complex mechanical, hydraulic and pneumatic subsystems, and also enable advanced electric armament systems. Improved power sources will support the individual soldier by permitting longer duration missions and reduced weight borne by the soldier. Space based operational capability improvements include a more electric architecture for responsive and affordable delivery of mission assets, and powering space based radar systems.

High power and energy densities, high rate capability, scalable to all power levels, will maximize performance, enhance fuel efficiency and enable future high power weapons and sensor systems on legacy and next generation vehicles and platforms.

The following topic areas were developed by the Energy & Power Community of Interest which is comprised of senior representatives from the Services and the Office of the Director, Research Directorate. The topics will address Department of Defense energy and power technology goals.

- Multi-Device (high power & energy dense device) operation to provide better cycle life.
- Innovative thermal management/heat sink technologies
- Battlefield/environmentally tolerant flywheel systems
- Thermal tolerant power electronic interface, with innovative enhanced power and fault handling, self-diagnostics, power line diagnostics.
- Intelligent power management

The Energy and Power Technology topics are:

OSD12-EP3	Energy Storage Enclosure Technologies for High Density Devices
OSD12-EP4	Tactical Power Plant Multi-Generator Intelligent Power Management Controller
OSD12-EP5	Dynamic Time and Frequency Domain Modeling of Aircraft Power System with Electrical Accumulator Units (EAU)
OSD12-EP6	Cylindrical Geometry Energy Storage Cooling Architectures
OSD12-EP7	Militarized Power Line Communication

Cyber Trust, Resiliency, Agility, and Assuring Missions Technology Focus Area

The DoD considers cyber to be a domain of conflict comparable to air, sea, land, and space. Not only does it have its own cyber-specific goals to defend information systems, but information technology is integral to all other military systems, and its unimpeded operation is critical to their success. Recognizing this, sophisticated and persistent adversaries can be expected to make determined assaults on the information technology supporting the DoD's capabilities. To take advantage of rapid technological advances in industry, DoD systems make extensive use of commercial off-the-shelf (COTS) hardware and software. While custom technology is used to meet DoD-unique needs, using general-purpose commodity technology for many functions allows cost-effective gains in the capabilities that make the DoD one of the world's most technologically advanced and effective forces. These gains, however, come at the price of creating systems that are ever-more complex, harder to make secure, and based on information technology that is equally available for adversaries to examine for vulnerabilities and means of compromise. Avenues of approach are available to adversaries to exploit vulnerabilities through interconnected networks and through the global supply chain for commercial technologies. DoD information technology and systems thus must be able to operate successfully in an environment continually and seriously contested by cyber attackers.

The goal in the cyber domain is to develop techniques for ensuring trust, resiliency, and agility, and to assure that missions for which the DoD relies on information technology can be conducted successfully despite incessant attempted incursions and even successful cyber attacks on the underlying technologies and systems. The amount of effort required for adversaries to carry out attacks that have appreciable effects needs to be driven higher and higher. Innovations are needed to make the DoD's information systems harder to pin down, harder to target, and more resilient to concerted attack.

The DoD seeks to develop ways of building features and architectural provisions into hardware, system software, and applications that make systems and networks more difficult to damage, more maneuverable to move out of the path of attacks, and more able to withstand damage and still perform their functions. The successful operation of the DoD's systems must not depend upon preventing or detecting every cyber attack in order to counter it. Networked systems must persevere, contain effects of incursions, blunt and frustrate attacks, and allow us to hunt and isolate adversaries within our networks, at Internet speeds.

Within this broad context, the following are areas of particular interest:

- Trust: Methods for establishing a known degree of assurance that devices, networks, and cyber-dependent functions perform as expected, despite attack or error. These could include innovative techniques for analysis of systems; models and protocols for establishing, evaluating, and sustaining the appropriate level of trust among devices, components, or users in distributed interactions; innovative authentication models and protocols; and trust metrics and infrastructures.
- Resilient infrastructure: Techniques to withstand cyber attacks, and sustain or recover critical functions. These may include static or dynamic techniques to make system tasks more difficult to target and disrupt through controlled use of unpredictability, diversity, dispersion, randomness, redundancy, unpredictability, dispersion, and tolerance in systems processing, interaction, and storage. In addition, they may include automated ways to rapidly restore systems and information to an effectively functioning state despite compromised elements.
- Agile operations: Techniques for dynamically reshaping cyber systems as conditions/goals change, to escape harm. These may include techniques and tools that enable defenders to shape and minimize the attack space, to modify or negate aspects of systems that adversaries may have discovered through advance reconnaissance, and to take action to block, disrupt, remove, or counter adversary actions. For instance, they may include techniques for polymorphism,

obfuscation, and network agility.

- Assuring effective missions: Techniques for assessing and controlling the cyber situation in a mission context. These include decision support: analysis models and tools to enable human decision-makers to understand the state, operational implications, and course of action alternatives for systems undergoing cyber attacks and compromises, and to control the execution of options to counter them. They may also include models characterizing the dynamic dependencies of mission level functions on information technology components and methods for populating them.
- Military-grade hardware and protocols: hardened techniques and components for key system elements in situations where COTS is not sufficient, such as systems exposed to battlefield environments or those with cyber-physical effects.

An important additional challenge for these areas is that of understanding and validating the effectiveness of the techniques at scale, to inform the further development and improvement of the technologies and to guide their operational use. Additional areas of interest, therefore, are innovative techniques and metrics for rigorous experimentation and techniques for modeling and simulation of cyber defense-relevant elements of the networked systems environment.

In all of the above areas, techniques are needed that can accomplish the goals in the various networking environments in which the DoD operates, including wired, mobile, and cloud technologies, in enterprise, tactical, and embedded systems environments, and both Service-specific and joint operations.

Cyber Trust, Resiliency, Agility, and Assuring Missions Technology topics are:

OSD12-IA1	Cyber Evaluation and Testing Assessment Toolkit (CETAT)
OSD12-IA2	Multi-Abstractions System Reasoning Infrastructure toward Achieving Adaptive Computing Systems
OSD12-IA3	Metrics for Measuring Resilience and Criticality of Cyber Assets in Mission Success
OSD12-IA4	Novel Detection Mechanisms for Advanced Persistent Threat
OSD12-IA5	Advanced Indications and Warnings (I&W) via Threat Feed Aggregation
OSD12-IA6	BGP FLOWSPEC Enabling Dynamic Traffic Resilience

Autonomous Systems that Reliably and Safely Accomplish Complex Tasks, in Operational Environments Technology Focus Area

As the DoD continues to develop a more agile and responsive force, capable of rapidly supporting dynamic missions in hostile environments, the military's requirement for smart, safe, and reliable autonomous systems is increasing.

In static environments, with static missions, today's automation-based technology is largely sufficient to meet many manufacturing and information processing objectives. However, in military situations, where dynamic environments collide with dynamic mission objectives, automation can only support a small fraction of DoD's autonomy requirements. Autonomous systems of the 21st Century must be able of rapidly adapting to uncertain and complex situations. They must have the capability to self-direct their actions to achieve mission objectives, while maintaining a close teaming relationship with their human operators and autonomous system teammates.

<u>Although autonomous system requirements can vary across space, air, land, and sea operational domains, two high-priority technical challenges have emerged:</u>

- **Human/Autonomous System Interaction and Collaboration** must enable military operators to flexibly shape and redirect the plans, behaviors, and capabilities of highly complex distributed autonomous systems in real time to meet operational objectives in the dynamic battle space. We are just beginning to understand the interrelationships between human behavior, autonomous vehicles, and operational missions. Understanding how these entities relate to each other and optimizing the human-to-machine partnership is important to future success. Autonomous systems must be capable of human-like, natural, intuitive, and effective multi-modal interactions with human operators to meet rapid coordination and collaboration requirements. Autonomous systems must be capable of understanding the intent of team members, adversaries, and bystanders. The level of self-direction that a system is allowed to employ must be responsive and adaptable to operator requirements. Additionally, the decision making processes of autonomous systems must be transparent to human operators. Technical solutions that expand machine perception, reasoning, and intelligence may play key roles in developing more effective Human/Autonomous System Interaction and Collaboration. Technical solutions that optimize human-to-machine interactions for current and future autonomous systems are desired.

- **Scalable Teaming of Autonomous Systems** must allow robust self-organization, adaptation, and collaboration among highly heterogeneous platforms, sensors, and communication systems in a dynamic battle space. An understanding of how to optimize machine-to-machine teaming to more effectively accomplish multiple types of missions is critical. Optimized teaming will depend upon advanced sensing/synthetic perception across large numbers of distributed entities. Decentralized mission-level task allocation/assignment, planning, coordination/ control of heterogeneous systems for safe navigation, sensing, and mission accomplishment will be critical. Autonomous systems must safely and reliably practice active space (air, land, water) management operations in proximity to manned systems and units. Communication systems will need to adapt to bandwidth jamming and other operational challenges. Technical solutions enabling more effective teaming between multiple and/or heterogeneous autonomous systems will expand key military operational capabilities. Associated advances in machine learning, perception, reasoning and intelligence, applied to multiple mission types and contexts, may enable more efficient scalable teaming of autonomous systems.

- Also of strong interest are techniques and tools for testing, evaluating, verifying and validating these two technical capabilities. The DoD projects exponential growth in software lines of code and major advances in algorithm development in the coming years. Analyst tools that support effective and efficient certification and recertification of intelligent and autonomous control systems will enable timely technical transition.

Autonomous Systems that Reliably and Safely Accomplish Complex Tasks, in Operational Environments Technology topics are:

OSD12-AU1	Anomalous System Behavior Detection & Alert System for Operators of Multi-Vehicle, Multi-Sensor Autonomy
OSD12-AU2	Model Driven Autonomous System Demonstration and Experimentation Workbench
OSD12-AU3	Autonomous Landing Zone Detection
OSD12-AU4	Cooperative Autonomous Tunnel Mapping
OSD12-AU5	Fashioning of an Adaptive Workspace through Autonomous Services
OSD12-AU6	Autonomy for Seeking, Understanding, and Presenting Information

Innovative Approaches to Flexible Information-Centric Interfaces in Operations Technology Area

Improved sensors with higher and higher resolution have unleashed a torrent of data in today's operations. Data-centric systems drive rigid interfaces which are little more than symbols on a screen. Current technologies leave the human operators exasperated with an overload of "data" and a dearth of decision quality "information". Additionally, adaptive, real-time planning tools do not support rapid "Course of Action" analysis and the re-planning needed in today's dynamic environments. Displays are typically non-interactive and adapt little to changing needs of the decision-makers. The continued proliferation of high resolution sensors and platforms will only compound data quantity non-linearly. Innovative ideas are needed to convert the current data-centric interfaces into information-centric and task-centric interfaces which are matched to the mission needs and to the decision-making capabilities of the human. Tomorrow's interfaces must be contextually relevant, responsive to the roles and responsibilities of a particular operator, and easily tailor-able to the dynamic environment.

The need for intuitive, dynamic interfaces which are tailored to the decision-maker is nearly overwhelming and increasing nonlinearly. Furthermore, the increase of unmanned systems (UxVs) has created a demand for interfaces which enable the control of multiple UxVs by a single operator. The surge in robotic entities is creating strong needs for the ability to monitor and communicate with "smart" robots in dynamic environments – placing a huge burden on the operator. Innovative interfaces can help mitigate the additional workload. Current displays and interfaces are limited to a single UxV. Scalable, platform-independent interfaces, nonexistent today, are necessary for cross platform operation and multiple vehicle control. Another critical shortfall is the dearth of domain-agnostic performance metrics for both the UxV and its human operator. A sometimes overlooked research area of interfaces is the capability to simulate the interfaces between humans and the systems (including robotics) they control. Realistic simulation of the interface and the resultant interactions are key to setting interface requirements and to reducing timelines for the development of effective, efficient interfaces.

While current challenges in interfaces fall into three priority categories, . A common component of the intuitive interface runs through and connects them. The common denominator is the need for mission-centric information analysis and displays which provide actionable options or reasonable, easily interpreted, potential courses of action. This context sensitivity aspect of the displayed information must help the operator/analyst to relate the information to the commander's intent and enable efficient, accurate decisions.

- Interfaces must provide intuitive interaction between the operator and the UxV system. The quality of the interaction is driven by an appropriate understanding from high fidelity operator state models and from equally well understood models of the remote system. Challenges exist in developing these models to the level where the interface, and its underlying assumptions, can accurately anticipate operator requests and propose courses of action for the human decision-maker. Paramount to the successful of any interface is the degree to which the operator "trusts" the information on the interface.
- The operator/decision-maker is THE central node in the overall operational success. Intelligent, adaptive aiding of the operator/decision-maker must aid, not complicate, each action which leads to a decision. Techniques are needed to measure, assess, and modify, if necessary, the operator's mental and physical state. The interface may need to develop operator-state assessments via successful and unsuccessful real-time interactions with the operator. The operator model would include measures of the operator state via natural, multimodal bilateral interfaces (e.g., gesture, eye movement, natural language dialogue, etc.)
- Progress in the first two challenges will contribute to solutions for the advanced teaming of human and machine. Key shortfalls exist in the representation and interface frameworks to capture and interpret (to a predetermined level of certainty) the goals and intentions of the

operator. Techniques to integrate the low-level operator models into the overall operator-machine interaction model present formidable obstacles.

Innovation opportunities abound as the Department moves forward to simplify interfaces between highly complex operators and equally complex systems. Advances in operator-state and machine-state modeling are required before effective integration of the two models can lead to increased synergy between humans and their operational environments via situation sensitive adaptive interfaces. Likewise, the need for operationally relevant, easily interpreted mission-centric information is a critical single point node for effective, efficient decision-making and the subsequent operationally relevant control of UxVs and robotic systems. The two are inseparable.

Innovative Approaches to Flexible Information-Centric Interfaces in Operations topics are:

OSD12-HS1	Human Computer Interfaces for supervisory control of Multi-mission, Multi-Agent Autonomy
OSD12-HS2	Naturalistic Operator Interface for Immersive Environments
OSD12-HS3	Natural Dialogue – based Gesture Recognition for Unmanned Aerial System Carrier Deck Operations

Tools for Engineering Resilient Systems Technology Area

Research Goals/Focus Areas

The envisioned ecosystem needs both automated and human-guided capabilities to (a) evaluate sensitivities and risks; (b) perform smart sampling of the trade spaces; (c) rapidly prune trade spaces; and (d) summarize surrogate models to provide "impedance matching" necessary for even pruned analyses to run in acceptable performance bounds.

The following are some selected areas of research:

- **Handling unanticipated couplings between domains in complex systems**. This is the result of emergent behavior in that complex systems display behaviors that cannot be predicted based on the behaviors of their individual parts. Adding new capabilities in one domain invariably leads to impacts in others. For example faster processors, or improved self diagnostics, may increase power consumption and consequently reduce lifetime. Capabilities are needed make humans the coordinators and controllers of proposed engineering processes rather than rather sole initiators of questions and the sole maintainers of checklists of questions. Without these, we will continue to be surprised by the situations and the interactions we failed to anticipate. Also needed are tools that automatically provide tools invoked by those processes with input from surrogate sources and from multiple databases which use differing schemata, hierarchies, and attributes.

- **Open Development Solutions ---** Many DoD development environments already exist, for specific disciplines and trade spaces. Desired environments need to support workflows combining tools that span multiple sources (commercial, open source, government, and academic) to allow interactive, collaborative development and evaluation of candidate concept of operations scenarios and their system implications. Innovative trusted hosting solutions are encouraged that will enable multi-vendor, contractor and government access. The challenge is develop a secure, commercially viable solution with low barriers of access to small and medium size DoD contractors.

- **Visualizing multidimensional tradespaces in manners that enable human-in-the-loop manipulation and control**. This includes methods to: (a) slice the design space and visualize multidimensional tradeoffs, beyond 2D Pareto front and 3D Pareto surface; (b) find near- Pareto optimal solutions which are in addition robust to changes in capabilities, performance parameters, and time/cost constraints; and, (c) increase confidence that the tradespace has been sufficiently bounded and populated.

- **Managing sensitivities and trades objectively**, including methods for: (a) quantifying currently subjective system attributes, e.g., reliability, survivability, manufacturability, integration, etc.; (b) removing or reducing the subjectivity associated with weightings on measures of performance and effectiveness, as well as assessing the sensitivity of these stakeholder desires to system capability; (c) assessing the sensitivity of design alternatives to changes in design parameters, requirements, and technologies; and, (d) Predicting subsystem and system-level variances based on uncertainties at the component level.

Tools for Engineering Resilient Systems topics are:

OSD12-ER1	Evaluating Component Interactions Within Complex Systems
OSD12-ER2	Functional Allocation Trades Between Hardware and Software

Data-to-Decisions Technology Area

Background/Challenge

On April 19, 2011, the Secretary of Defense issued a memo identifying 7 S&T priorities for strategic investment planning, Data-to-Decisions, is one such initiative and seeks shorten the cycle time from data gathering to decision making to address the Department's enduring challenge to insure that the right, relevant and actionable information is provided to achieve the desired effect. Within the DoD military decisions are impacted by available information from the tactical edge all the way up through strategic level decisions and direction. From an analytical perspective, improved sensor performance with the increasing availability and relevance of open source information compounds the amount of information available for analysis and decision making.

With this abundance in data, the need to discover and identify threat signatures in complex, incomplete, imprecise and potentially contradictory large data sets has become a critical issue in military decision-making as it is beyond the abilities of humans to read and assimilate such large data sets and create comprehensive analytic products that leverage them. Said another way, as the amount of data grows, extracting actionable information and fusing these results with relevant contextual or situational information to inform effective and timely action becomes progressively more challenging. Given that the 2012 National Security Strategy has indicated that "for the foreseeable future, *the United States will continue to take an active approach to countering [threats] by monitoring the* activities of non-state threats worldwide[…]" it is clearly a matter of National Security that the DoD strive to overcome these challenges to support the defense objectives of the Administration.

Research Goals/Focus Areas

This year we are seeking topics for each of the three research focus areas described below as identified through OSD's coordination with the Data-to-Decisions PSC, DoD researchers and operators, and the Data-to-Decisions PE.

Intelligent Sensing

To advance surveillance for predictive intelligence, the Department of Defense trend has been toward evolutionary mechanical development increasing the capability of data collection devices so that they may deliver many high resolution data points in complex formats collected over long periods of time. As a result the Department has placed significant value on the volume and "precision" of data, rather than the ability of the sensor output to affect predictive intelligence or to meet the needs of a mission. This causes more data rather than data that is truly "better" -- exchanging quality for quantity thus creating the "Large Data Problem". In response to the "Large Data Problem", the Department of Defense has currently focused on S&T needed to handle the load of data through faster processing, automated analysis, allowing analysts and operators to get this overwhelming volume of data quickly, rather than using a decision based approach that focuses on tailoring the collection of data to the needs of the mission and analyst. However getting to the data faster, and seeing more data through automated means cannot resolve some of the most difficult challenges that have been created— the DoD will continue to seek a predictive analytics. Alternatively, in order to eliminate the creation and need of large data sets a capability for intelligent sensing and surveillance can be pursed for time critical applications.

Based upon recent interaction with DoD researchers and operators, it is believed that in order to achieve intelligent sensing and surveillance the DoD must begin with focusing on the tasking aspect of the TCPED (task, collect, process, exploit, disseminate); and assumes that methods for focused tasking will result in lower volumes of high quality data. Such methods should focus on resolving the challenges in tasking to produce high quality data include capabilities that allow tasking managers to optimally "architect" a collect using existing resources to ensure that the collection is conducted in an optimal way considering the needs of the mission through communication with the sensor, capabilities to enable assets to conduct self-quality assessments that reduce the promulgation of bad data and self-cue a re-tasking until the proper quality is achieved, and the ability for multi-modal assets to communicate and cue one another to enable downstream data fusion.

Research in the areas of mathematics, computer science, information theory, control theory, network theory and distributed sensor resource management as well as multidisciplinary areas that may prove promising are of interest. In addition to the application of research methods and approaches, it is important to evaluate the impact of these efforts areas with regards to the way they change how tasking is designed and data is collected to positively impact decisions. Topics can come from any applicable domain defined by the new National Security Strategy. Novel approaches leading to the invention of new functions for how information needs are analyzed, tasking is designed, and data is collected, and used should be emphasized.

Text Analytics

Text analytics is a growing field and central to the war on insurgents. They form a fundamental basis for Open Source Intelligence, as well as the means for logging, storing and retrieving important information derived from warfighter interactions with local populations. One aspect of text analytics of interest to the DoD is Natural Language Processing (NLP). Natural language is an extraordinarily difficult problem in the general case: computational algorithms are not currently suited to understand complex ideas from text, such as emotional underpinnings of the written word. But given a limited application domain, it is likely that we can make significant progress in understanding the free form text sufficiently that analysts can be empowered to make queries in large unstructured or semi-structured datasets, including foreign language data, and including queries based on concepts rather than simply on key words and phrases. In order to advance the text analytics capability the DoD must understand the state-of-art in language processing and machine translation, identify gaps and conduct research to reduce these technical shortfalls.

Research in the areas of mathematics, computer science, language processing, machine translation, sentiment analysis and gisting as well as multidisciplinary areas that may prove promising are of interest. In addition to the application of research methods and approaches, it is important to evaluate the impact of these efforts areas with regards to the way they change how the text analytics process is improved to positively impact decisions. Topics can come from any applicable domain defined by the new National Security Strategy. Use of relevant DoD text sources (both open source and DoD-owned) should be emphasized.

Decision Process Understanding

The Department of Defense (DoD) and the Intelligence Community (IC) have devoted considerable resources to improve intelligence collection and analysis, adapting these to address today’s threats. Solutions and algorithms developed to facilitate large data management, while successful in the acquisition of data, have been constrained by problems of human-system integration as the solutions developed to support military decisions remain based on an information fusion model that assumes that if a person understood the physical space they could make the ‘right’ decision. However this assumption should be challenged as it may not possible to fully understand the physical space as data will be “dirty”, inconsistent, or undiscoverable. Further, given all the data about the physical space it is not clear that the ‘right’ decision will be made in every instance. Therefore, to achieve the goals of the Data-to Decisions priority, the DoD must take advantage of the understanding in the social and cognitive sciences realm and inject that understanding into current tools and develop future analyst, operator, and commander decision aids upon that foundation.

Research in the areas of social and cognitive science, mathematics, computer science, information theory, decision science, operations research as well as multidisciplinary areas that may prove promising are of interest. In addition to the application of research methods and approaches, it is important to evaluate the impact of these efforts areas with regards to the way they change how data is collected, processed, or shared to positively impact decisions. Topics can come from any applicable domain defined by the new National Security Strategy. Novel approaches leading to the invention of new functions for how information needs and decision impact are analyzed, quantified, and reported should be emphasized.

Data-to-Decisions topics are:

OSD12-LD1	Autonomous Sensing and Deciding Framework Processor
OSD12-LD2	Fusing Uncertain and Heterogeneous Information – Making Sense of the Battlefield
OSD12-LD3	Data to Decisions, Information Systems Technology
OSD12-LD4	Intuitive Information Fusion and Visualization
OSD12-LD5	Extracting Event Attributes from Unstructured Textual Data for Persistent Situational Awareness
OSD12-LD6	Text Analytics from Audio
OSD12-LD7	Tactical Information Management
OSD12-LD8	Semantic Targeting for Open Source Intelligence Analysis

OSD SBIR 12.3 Topic Index

OSD12-AU1	Anomalous System Behavior Detection & Alert System for Operators of Multi-Vehicle, Multi-Sensor Autonomy
OSD12-AU2	Model Driven Autonomous System Demonstration and Experimentation Workbench
OSD12-AU3	Autonomous Landing Zone Detection
OSD12-AU4	Cooperative Autonomous Tunnel Mapping
OSD12-AU5	Fashioning of an Adaptive Workspace through Autonomous Services
OSD12-AU6	Autonomy for Seeking, Understanding, and Presenting Information
OSD12-EP3	Energy Storage Enclosure Technologies for High Density Devices
OSD12-EP4	Tactical Power Plant Multi-Generator Intelligent Power Management Controller
OSD12-EP5	Dynamic Time and Frequency Domain Modeling of Aircraft Power System with Electrical Accumulator Units (EAU)
OSD12-EP6	Cylindrical Geometry Energy Storage Cooling Architectures
OSD12-EP7	Militarized Power Line Communication
OSD12-ER1	Evaluating Component Interactions Within Complex Systems
OSD12-ER2	Functional Allocation Trades Between Hardware and Software
OSD12-HS1	Human Computer Interfaces for supervisory control of Multi-mission, Multi-Agent Autonomy
OSD12-HS2	Naturalistic Operator Interface for Immersive Environments
OSD12-HS3	Natural Dialogue – based Gesture Recognition for Unmanned Aerial System Carrier Deck Operations
OSD12-IA1	Cyber Evaluation and Testing Assessment Toolkit (CETAT)
OSD12-IA2	Multi-Abstractions System Reasoning Infrastructure toward Achieving Adaptive Computing Systems
OSD12-IA3	Metrics for Measuring Resilience and Criticality of Cyber Assets in Mission Success
OSD12-IA4	Novel Detection Mechanisms for Advanced Persistent Threat
OSD12-IA5	Advanced Indications and Warnings (I&W) via Threat Feed Aggregation
OSD12-IA6	BGP FLOWSPEC Enabling Dynamic Traffic Resilience
OSD12-LD1	Autonomous Sensing and Deciding Framework Processor
OSD12-LD2	Fusing Uncertain and Heterogeneous Information – Making Sense of the Battlefield
OSD12-LD3	Data to Decisions, Information Systems Technology
OSD12-LD4	Intuitive Information Fusion and Visualization
OSD12-LD5	Extracting Event Attributes from Unstructured Textual Data for Persistent Situational Awareness
OSD12-LD6	Text Analytics from Audio
OSD12-LD7	Tactical Information Management
OSD12-LD8	Semantic Targeting for Open Source Intelligence Analysis

OSD SBIR 12.3 Topic Descriptions

OSD12-AU1 TITLE: Anomalous System Behavior Detection & Alert System for Operators of Multi-Vehicle, Multi-Sensor Autonomy

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Enable decision support for the supervisory control of highly autonomous systems by developing one or more Behavioral Anomaly Detection Services. These algorithms, embodies as re-useable services would enable human supervisors to exploit, benefit from, and interact with technologies on the basis of their behavior, without requiring a deep understanding of the functions in the underlying systems.

DESCRIPTION: The focus of this effort is to provide a formal mechanism for building a higher level language that will make anomaly detection technology relevant and useful to the human supervisor who must manage remote autonomous entities on an intermittent, asynchronous basis in emerging autonomous systems. The output of this effort should define, structure, and enable efficient information transaction mechanisms for persons responsible for supervisory control. It is expected that successful decision support solutions will resemble those of human supervisory control systems in use in industry today.

Research will be needed to inform the specification of system behavior and the development of anomaly detection algorithms, including models of system normalcy, deviations from normalcy, and/or mission context. A central challenge in this domain will be determining what behavior constitutes significant deviations from normal behavior, and developing algorithms that characterize those deviations. Deviations in the face of dynamic missions, and operational contexts will be difficult to define. The model must be tailored to needs of user tasks and decisions, and tuned to provide adequate information for the human decision maker so as to maintain trust in the automation (2, 3, 4) and avoid the documented pitfalls of automation (5, 6). A user interface layer and an associated dialog processes will be needed to structure and enable interactions between users and anomaly detection algorithms.

The proposed research will develop techniques to enable the description of desired behavior in terms of goals and objectives, and characterize undesired anomalies in the behavior of command and control systems. The desired solution should be applicable to anomaly detection in a variety of command and control domains, such as multi-echelon military command and control, and the management of autonomous vehicles and systems. For example, for the management of multi-UAV systems, the algorithms will detect anomalies to either make corrections within the UAVs' mission scope or alert the operator and provide alternative courses of action. Resultant capabilities are expected to produce cost saving through enabling reduced manpower as Autonomous Warfare evolves from multiple operator vehicles with teams of human controllers, to a single operator managing multiple systems.

PHASE I: Propose a formal structure to represent the desired and undesired behaviors of an autonomous vehicle system. Describe how advanced and specialized anomaly detection algorithms would be employed to assess system normalcy and deviations from normalcy for a specific autonomous system and mission context. Describe how a system developer would incorporate these algorithms into a decision support framework, as informed by the fields of cognitive science and human supervisory control of automation, and apply it to the detection of behavior anomalies in human supervision in a command and control system. Provide a conceptual design and feasibility demonstration of a prototype with wireframe design elements to illustrate interactions between a human supervisor and anomaly detection technology. Define metrics for evaluating the utility and efficiency for using the proposed behavioral transaction mechanisms in managing one or more autonomous vehicles in a system.

PHASE II: Develop a prototype design of the autonomy management system based on the Phase 1 behavior descriptions. Demonstrate the use of the formal behavior structures in managing an autonomous system by a human supervisory controller. Designate appropriate open source software, a Concept of Operations for their use is a representative mission(s), provide documentation to enable experimentation with Subject Matter Experts and provide data collection and analysis techniques to support the evaluation of metrics defined in Phase 1. Describe effectiveness of autonomy management in a notional or simulated multi-mission adversarial environment and empirically demonstrate improved operator responsiveness to real-time changes in mission execution and goals.

Provide details on how the technology would integrate with a selected autonomous platform and outline a transition plan.

PHASE III DUAL USE COMMERCIALIZATION: Refine the prototype and make its features complete in preparation for transition and commercialization. In addition to the DoD, there will be an increasing demand for supervision of autonomous systems in the commercial sector, such as the process control domain and commercial mining industries, and in federal and state agencies such as law enforcement, emergency management, and border protection. These domains could benefit significantly from the application of the solution developed in this effort.

REFERENCES:
(1) Department of Defense. (2011). Unmanned Systems Integrated Roadmap FY2011-2036.

(2) Lee, J.D., & See, K.A. (2004). Trust in automation: designing for appropriate reliance. Human Factors, 46, 50-80.

(3) Meyer, J. (2001). Effects of warning validity and proximity on responses to warnings. Human Factors, 43, 563-572.

(4) Meyer, J. (2004). Conceptual issues in the study of dynamic hazard warnings. Human Factors, 46, 196-204.P

(5) Parasuraman, R., & Riley, V. (1997). Humans and Automation: Use, Misuse, Disuse, Abuse. Human Factors, 39, 230-253.

(6) Cummings, M.L. (2004). Automation bias in intelligent time critical decision support systems. Paper presented at the AIAA 3rd Intelligent Systems Conference, Chicago.

KEYWORDS: Anomaly Detection, Supervisory Control, Autonomous Systems, Decision Support

OSD12-AU2 TITLE: Model Driven Autonomous System Demonstration and Experimentation Workbench

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a systems engineering tool to automate storage of data for autonomous systems and to deploy components necessary to implement the system.

DESCRIPTION: Large amounts of data are generated on autonomous systems including but not limited to imagery data, geospatial information, platform health data, and specific mission-related sensor data. Current software used to classify and utilize these data sets is largely uncoordinated across the multiple data inputs. Human operators must fill the technical gap via in-depth cross-data analysis, taking context into account. Current autonomous systems have limited ability to self-govern their data storage, perform context-driven data analysis, and share data with other autonomous platforms and/or human operators. New and/or improved software tools, computational methods, and laboratory technologies are necessary to bridge these gaps and enhance ongoing efforts. Software capable of integrating a wide range of disparate data sources and computational or mathematical methods and tools for connecting or merging models and creating bridges between models of different scale are needed for a better understanding of the processes underlying autonomous operation in a highly uncertain environment, as might be generated in a disaster event. In addition, technologies are needed to generate supporting data that enable these models to accurately represent the processes they model. Understanding and quantifying multi-component, interactive processes at the component level can be limiting. Quantitative methods and technologies to measure component and multi-component collective behavior in simulated virtual and physical environments are needed. This initiative will support the development of these enabling software packages, modeling methods, and technologies.

PHASE I: The first phase consists of investigating and identifying model elements and their relationships (meta-models), as well as prototyping a graphical language to manipulate the models within the Autonomous System Demonstration and Experimentation Workbench. Model elements at the highest level include, Autonomous Key Functions, Mission Task Analysis and Test and Experiment Strategy where key functions support mission task analysis, which drive the Test and Evaluation strategy. Next, the system should support assembling collections of key functions (feature modeling) that support requirements based on mission task analysis. The collections should be combinable by an analyst, using a graphical domain specific language, to determine operationally suitable experimental system designs, cost reports, collections of specifications, simulation decks and eventually an experimental system. The system should also be able to catalog and archive these analytical exercises.

The Phase I deliverables should include a final Phase I report that will include the algorithms and hardware needed to implement the workbench, as well as requirements for the Graphical Interface. Feasibility of the proposed approach should be demonstrated through simulation or implementation.

PHASE II: Phase II shall produce and deliver a prototype Autonomous System Demonstration and Experimentation Workbench. The Phase II system shall be demonstrated using meta-models and data structures defined in Phase I. The prototype should include analysis examples including:
• Creating experimental systems for a set mission task analysis efforts, such as Urban Driving, gas monitoring in an urban environment or forest fire fighting.
• Creating a list of acceptable sensors for a particular task, i.e. Lidar's capable of safely detecting oncoming traffic at 30 MPH for a passing task.
• From the list of acceptable components, extract the cost of each.

The Phase II prototype should show proof-of-concept by applying the methodology to a use case, such as the Urban Challenge. This will include mission tasks, as well as key functions to realize this task. The key functions should be annotated with cost data, specifications and simulation components for an open-source simulator.

PHASE III DUAL USE COMMERCIALIZATION: Transition the work of phase II to a DoD development effort and potentially a homeland defense / first responder effort. Teleoperated and semi-autonomous systems are already in use for hazardous and remote missions. Improved autonomy should reduce training time and increase ease of use. Autonomous systems are also in limited use in manufacturing fabrication and logistics. One problem area is reprogramming such systems for changes in production schedule or component design. Better operator interface designs should reduce the skill levels required. Thus, wider use of autonomous systems from existing manufacturers and newly formed firms is probable.

Potential commercial applications of this technology include designing autonomous processes for materials handling and or security in potentially hazardous environments.
Keywords: Autonomy, Navigation, Behavior, Perception, Sensing, Collaboration, Unmanned Vehicles, Model Driven Design, Task Analysis, Engineering Test

REFERENCES:
1. Giger, Kandemir, and Dzielski, "Graphical Mission Specification and Partitioning for Unmanned Underwater Vehicles", JOURNAL OF SOFTWARE, VOL. 3, NO. 7, pp 42-54 OCTOBER 2008.

2. Sprinkle, Jonathan; Eklund, J. Mikael; Gonzalez, Humberto; Grøtli, Esten Ingar; Upcroft, Ben; Makarenko, Alex; et al., "Model-based design: a report from the trenches of the DARPA Urban Challenge", published with open access at Springerlink.com, March 2009.

3. K. Czarnecki, Model Driven Architecture, OOPSLA Tutorial, www.sts.tu-harburg.de/teaching/ss-08/SEng/07-MDA.pdf.

4. Generic Modeling Environment, http://www.isis.vanderbilt.edu/projects/gme, 09 April 2007.

5. Smuda, W, “Rapid Prototyping of Robotic Systems”, Naval Postgraduate School Dissertation, June2007.

KEYWORDS: Autonomy, Navigation, Behavior, Perception, Sensing, Collaboration, Unmanned Vehicles, Model Driven Design, Task Analysis, Engineering Test

OSD12-AU3 TITLE: Autonomous Landing Zone Detection

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

OBJECTIVE: Develop algorithms that enable Small Unmanned Air Systems (SUAS) to autonomously identify landing zones to land and re-launch.

DESCRIPTION: Small Unmanned Air Systems (SUAS) are being developed for numerous applications, but size and weight constraints severely limit the endurance of such vehicles1, 2. Some of the missions of these vehicles could be extended by landing for certain periods, entering a low-power state, then re-launching as needed, especially in urban environments. Some technologies have been developed to provide landing gear hardware and flight controls suitable to allow autonomous landing of SUAS. A primary capability that has yet to be developed is the suite of autonomous behaviors necessary to determine when it is appropriate to land, identify a suitable landing zone (LZ), guide the SUAS to the LZ, determine when to re-launch, and re-launch. Portions of these functions could be performed by a human operator, but it is highly desirable to limit the burden on the operator in high-stress environments, or situations when an operator is responsible for multiple vehicles and functions. Therefore, a high level of autonomy is desired. One potential solution (though not required) is for an autonomous team of SUAS to cooperatively perform the landing task. In this scenario, one “control-ship” would identify the LZ and guide its teammate to it from a suitable vantage point. This would give the landing vehicle the benefit of multiple perspectives of its own pose relative to the LZ. While it may vary depending on the mission, the ideal LZ would be an elevated location with clear sight lines that would allow the vehicle to continue surveillance functions in a low-power state, while also retaining some potential energy for re-launch. An example of such a LZ would be the corner of a building’s roof top. Though solutions should not be limited to this, it is expected that software algorithms can be developed to recognize relevant features of an urban environment in the SUAS’ live video stream and analyze these features to identify potential LZs. The goal of this project is to begin to develop these autonomous behaviors, and demonstrate them in a simulated environment. Specifically, the machine perception, reasoning and intelligence functions of; 1) recognizing features such as roof tops, walls, corners, power lines etc., 2) evaluating them relative to over-arching mission goals to determine ideal LZ s, and 3) reasoning the optimal approach path to ensure a successful landing. While the eventual goal is a SUAS that can autonomously land and re-launch, the focus of this project is only to develop software that can identify potential LZs from a video feed.

PHASE I: The proposal for Phase I should study the feasibility of identifying suitable LZs from a video feed. To demonstrate this feasibility, a preliminary algorithm should be developed that identifies preferred LZs in representative flight video of an urban environment. Additional functionality may include evaluating and prioritizing potential LZs, though this is not required for Phase I.

PHASE II: In Phase II, the LZ detection algorithm will be matured and employed on a Government-furnished prototype quad-rotor SUAS equipped with suitable hardware and flight control capabilities to perform an autonomous landing experiment. The algorithm will be required to identify a suitable LZ, evaluate it relative to other potential LZs, and geo-locate it sufficiently to provide guidance instructions to the flight control software.

PHASE III DUAL USE COMMERCIALIZATION: Development of such autonomous machine perception behaviors and implementing them on a prototype vehicle will provide any potential business with valuable experience in a growing field. Commercial applications of the technology may include long-endurance surveillance missions in support of private security and community policing sectors, monitoring wildlife, detection of forest fires, etc.

REFERENCES:
1. Office of the Secretary of Defense, “Science and Technology Priorities for Fiscal Years 2013-2017 Planning.” April 19, 2011.

2. Air Force Research Laboratory, “Air Force Science & Technology Plan”, 2011.

3. Desbiens, A. L., and Cutkosky, M. R., “Landing and Perching on Vertical Surfaces with Microspines for Small Unmanned Air Vehicles,” Journal of Intelligent and Robotic Systems: Theory and Applications, Vol. 57, Nos. 1–4, 2009, pp. 313–327.

4. Cory, R., and Tedrake, R., “Experiments in Fixed-Wing UAV Perching,” AIAA Guidance, Navigation and Control Conference and Exhibit, Honolulu, HI, AIAA Paper 2008-7256, Aug. 2008.

5. Reich, G. W., Eastep, F. E., Altman, A., and Albertani, R., “Transient Post-Stall Aerodynamic Modeling for Extreme Maneuvers in MAVs," Journal of Aircraft, Vol. 48, No. 2, 2011, pp. 403-411.

KEYWORDS: autonomy, machine perception reasoning and intelligence, UAV, SUAS, perching

OSD12-AU4 TITLE: Cooperative Autonomous Tunnel Mapping

TECHNOLOGY AREAS: Air Platform, Sensors, Human Systems

OBJECTIVE: Develop a command and control algorithm to allow aerial robotic scouts to cooperatively explore an unknown indoor environment, and communicate their findings to each other and their human operators.

DESCRIPTION: There are numerous applications for unmanned/robotic systems operating in complex urban or indoor environments1, 2. A high level of autonomy is desired to reduce operator workload, and vision-based navigation systems must be used in lieu of GPS. Numerous research efforts are underway to develop novel vision-based navigation systems such as Simultaneous Localization and Mapping (SLAM) in size, weight and power packages suitable for deployment on small air vehicles3, 4, 5. To maximize the effectiveness of robotic systems, cooperative behaviors between several members of a team should be developed as well. However, it is critical to ensure that as the team grows, the operator burden does not. Therefore, the goal of this project is to develop cooperative behaviors between autonomous aerial scouts, thus enabling autonomous teams of unmanned systems to perform complex missions. Specifically, it is required that algorithms be developed for cooperative exploration of unknown indoor environments by multiple small aircraft (rotorcraft, fixed wing, etc). These cooperative algorithms would allow team members to share information, including map data, team member status, and notable features of the environment, for example. Developing the aircraft and the vision-based navigation systems for them is not within the scope of this project. Any such vehicles that are required will be provided by the government. These aircraft have strict payload limitations and limited range and endurance, so any proposed algorithms must have minimal computational requirements. Furthermore, the search algorithms should have an optimizing function that seeks to maximize searchable area in minimal time. It may be advantageous to disperse various capabilities among several specialized team members so that no individual would have the same level of capabilities of the team in aggregate. For example, certain team members could act as communication relays while others carry specialized sensors, etc. It is expected that such delegation schemes would be studied under this project.

PHASE I: Study the feasibility of cooperatively searching indoors with aerial robots, to include developing a rudimentary path planning algorithm (in software only) that would be the basis for a more advanced command and control algorithm in the future. This algorithm should be tested in a simulated environment to assess its potential for further prototyping, and should account for the challenges of indoor operations such as intermittent wireless communication and obstacles.

PHASE II: In Phase II, a more advanced command and control algorithm will be employed on a team of autonomous aerial scouts and demonstrated in a representative indoor environment. These vehicles will be provided by the Government with a vision-based navigation capability to avoid obstacles and map surroundings. The offeror’s algorithm will be required to fuse data from each team member, perform coordinated path planning, and send high-level navigation instructions to the team members.

PHASE III DUAL USE COMMERCIALIZATION: Development of such cooperative exploration algorithms and implementing them on prototype vehicles will provide any potential business with valuable experience in a growing field. There is significant potential for follow-on work in cooperative behaviors that could follow from this project. Commercial applications of the technology may include search and rescue functions in dangerous environments including earthquake rubble, avalanches, and collapsed mines, etc.

REFERENCES:
1. Office of the Secretary of Defense, "Science and Technology Priorities for Fiscal Years 2013-2017 Planning." April 19, 2011.

2. Air Force Research Laboratory, "Air Force Science & Technology Plan", 2011.

3. S. Shen, N. Michael, and V. Kumar. "Autonomous indoor 3D exploration with a micro-aerial vehicle." Proc. of the IEEE Intl. Conf. on Robot. and Autom., Saint Paul, MN, May 2012. To Appear.

4. A. Huang, A. Bachrach, P. Henry, M. Krainin, D. Maturana, D. Fox, and N. Roy "Visual Odometry and Mapping for Autonomous Flight Using an RGB-D Camera." Int. Symposium on Robotics Research (ISRR), Flagstaff, Arizona, USA, Aug. 2011

5. S. Shen, N. Michael, and V. Kumar. Autonomous multi-floor indoor navigation with a computationally constrained MAV. In Proc. of the IEEE Intl. Conf. on Robot. and Autom., Shanghai, China, May 2011.

KEYWORDS: autonomy, scalable teaming of autonomous systems, simultaneous localization and mapping, UAV, cooperative control

OSD12-AU5 TITLE: Fashioning of an Adaptive Workspace through Autonomous Services

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop robust technologies that promote an "impedance match" or "human-IT partnership" that increases the analyst's agility and compliment the human abilities. Traditional approaches to human-computer interaction focus on relatively simplistic human behavior (e.g., key strokes, mouse clicks, etc.). This effort will concentrate on the analyst's experience by providing a means to address task off-loading, and adapting the workspace context based on the analyst practices and data content. This effort is accomplished by a collaboration between the human and machine, not making computers mimic people, but leveraging each of their strengths, talents and capabilities within a harmonious human-IT partnership.

DESCRIPTION: Intelligence analysts currently cannot efficiently manage the amount of multi-modal (i.e. multiple file formats – structured and unstructured text, video, photos, etc) and multi-lingual data available for analysis. As a result, exploitation of information contained in unanalyzed data remains undiscovered, or is delayed beyond the point where the information is no longer of any operational value. There is evidence supporting the importance of a wide field-of-view in generating a sense of immersion and presence within the data landscape. Immersion into this data landscape substantially increases human ability to navigate diverse land and complex virtual environments to establish and test hypotheses. While automated processes are promising, the real-world performance of the human analyst remains the gold standard. Human errors fall into three major classes: skill-based slips, rule-based mistakes, and knowledge-based mistakes. Impaired cognitive function is most likely to increase errors involving memory, reasoning, and judgment, leading to the uncritical or biased use of faulty knowledge, hasty decisions under stress, and memory blocks that lead to unacceptable performance delays. The effects of stress, fatigue, and task overloading cumulate over time, and cognitive states characterized by errors of judgment need to be detected before serious problems occur. As information load increases, for example, people take aggressive and potentially riskier steps to manage it, such as increasing their tolerance for error, delaying analysis, shedding tasks and filtering. Performance itself is a function of task demand level and a person's ability to manage information processing. Performance deterioration associated with increasing task difficulty indicates that cognitive capacity is finite, and has been conceptualized as a single resource or multiple resources. Performance in high workload, high throughput volume tasks such as image analysis can rapidly degrade in operational settings.

Ongoing reviews by analysts and researchers of the current state of R&D on how to support professionals in the Intelligence Community (IC) noted: (1) massive data overload, (2) cohort changes that include an “expertise gap,” (3) major changes in the tasks and data types that entail changes in jobs and roles, (4) paucity of truly human-centered information technology as analysts develop their own adaptations and workarounds.

PHASE I: The first phase will explore and develop an approach to the conception of the role of computers in an analyst’s activities. Identify a framework that will support the human-computer interaction as an integrated system and focus on support for high-order human activities such as skilled performance, complex learning and analysis. The framework should address how modeling and information analysis and comprehension can be viewed as a form of cognitive and collaborative work; identify patterns and broadening checks, and how to innovate the means for explicit and implicit collaboration across networks of analyst.

The Phase I deliverables should include a final Technical Report for Phase I that will include the system requirements, algorithms and hardware to implement an Analyst Workspace that Adapts to their requirements and needs. Feasibility of the proposed approach should be demonstrated thru an initial prototype or simulation.

PHASE II: Phase II shall produce and deliver a prototype of An Analyst Adaptive Workspace (A3W). The system shall demonstrate some of the concepts identified for the framework in Phase I such as how analysts can collaborate across networks, how analysis processes and products can better support decision making, policy and action loops such as time critical targeting and how to develop and support an integrated workflow across the entire range of analyst tasks and activities.

The Phase II prototype should show a proof-of-concept by applying the A3W to a Request for Information (RFI) to demonstrate the integrated workflow across analyst tasks, activities and networks.

PHASE III DUAL USE COMMERCIALIZATION: Transition this work in Phase II to an Intelligence Component such as NASIC for evaluation and use by Senior Analysts and as a training capability for new Analysts. The A3W should be viewed as an Assistant that understands the user’s knowledge and experience and adapts the workspace to them.

Potential commercial applications of the technology include supporting analysts in Law enforcement for use in cyber, and criminal investigation.

REFERENCES:
1. Woods, David D. and Hollnagel, Erik (eds.) (2005): Joint Cognitive Systems. Foundations of Cognitive Systems Engineering. Boca Raton, Florida, USA

2. Patterson, Emily S., Watts-Perotti, Jennifer and Woods, David D. (1999): Voice Loops as Coordination Aids in Space Shuttle Mission Control. In Computer Supported Cooperative Work, 8 (4) pp. 353-371.

3. Sarter, Nadine B. and Woods, David D. (1995): "From Tool to Agent": The Evolution of (Cockpit) Automation and Its Impact on Human-Machine Coordination. In: Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting 1995. pp. 79-83.

4. Endsley, Mica R., Klein, Gary, Woods, David D., Smith, Philip J. and Selcon, Stephen J. (1995): Future Directions in Cognitive Engineering and Naturalistic Decision Making. In: Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting 1995. pp. 450-453.

5. Corker, Kevin, Pew, Richard W., Cream, Bertram W., Smith, Barry R., Butler, Keith A., Day, Carroll N., Monk, Donald L., Young, Michael J. and Woods, David D. (1991): Evaluative Techniques for Automation Impacts on the Human Operator. In: Proceedings of the Human Factors Society 35th Annual Meeting 1991. pp. 1253-1254.

6. Weghorst, Suzanne and Furness, Thomas A. (1999): Special Issue on Virtual Environment Interaction (Editorial). In J. Vis. Lang. Comput., 10 (1) pp. 1-2.

7. Poupyrev, Ivan, Weghorst, Suzanne, Billinghurst, Mark and Ichikawa, Tadao (1998): Egocentric Object Manipulation in Virtual Environments: Evaluation of Interaction Techniques. In Comput. Graph. Forum, 17 (3) pp. 41-52.

8. Jeffrey M. Bradshaw, Hyuckchul Jung, Shri Kulkarni, Matthew Johnson, Paul Feltovich, James Allen, Larry Bunch, Nathanael Chambers, Lucian Galescu, Renia Jeffers, Niranjan Suri, William Taysom, and Andrzej Uszok, Kaa: Policy-based Explorations of a Richer Model for Adjustable Autonomy, Proceedings of the International Joint Conference on Autonomous Agents and Multi Agent Systems, 2005

9. Hyuckchul Jung, James Allen, Nathanael Chambers, Lucian Galescu, Mary Swift, William Taysom, Utilizing Natural Language for One-Shot Task Learning, Journal of Logic and Computation, 18(3): 475-493, Oxford University Press, 2008

KEYWORDS: impedance match, human-IT partnership, virtual environments, data landscape, cognitive states, human-centered

OSD12-AU6 TITLE: Autonomy for Seeking, Understanding, and Presenting Information

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop scalable computing algorithms capable of performing autonomous data discovery and analysis operations across different data modalities based on learning and/or training. Specifically, reduce the effect of operator information overload by autonomously gathering relevant information for decision-makers and drawing meaningful conclusions from massive amounts of data, from different sources, therefore optimizing human-agent interactions.

DESCRIPTION: Military decision makers must bring together multiple kinds of data: text, video, audio, images, etc. in order to glean meaningful findings to determine the correct military response. Today’s computing information systems are continuously bombarded with sensor, machine, and user generated data. The main challenge information analysts face today is how to triage the vast amounts of available data to ensure critical information is acted upon. This challenge will only increase as more kinds of data become available through the proliferation of mobile, online, and highly participatory digital technologies.

Future military capability that enables a robust understanding of the massive amount of available data will need to be able to solve two seemingly different, but inexorably linked problems. First, there is so much data available that the human capacity to understand it is simply overwhelmed, leading to decision paralysis. Second, technology proliferation has reduced the cost of entry to the information environment, making pertinent or contravening information elusive to even the most savvy decision makers, leading to decision hubris. Successful military decision-makers must walk a tight rope between considering enough facts to understand a problem in a balanced way, and causing undue delay by over-saturating their cognitive bandwidth.

As a result, this research topic seeks innovative ideas where emerging computing algorithms can be applied to intelligent information processing or autonomous sense making operations across multiple modalities of data. The basic goal is to develop information software platforms capable of performing autonomous, distributed data-mining that would enhance the performance, resilience, and decision making capabilities of the user by enabling autonomy within the information gathering, understanding, and presentation system itself. Special emphasis is on emerging algorithms that blend decentralized, distributed systems with data-mining and knowledge discovery approaches to enable new economies of scale when considering conclusions across massive, multi-modal, online, heterogeneous data. This is of interest for drawing conclusions from massive, online data sources such as (but not limited to) high-resolution military sensors, open-source data from the internet, and partially public information from participatory social and mobile technologies.

PHASE I: Research and develop an innovative approach to meet the SBIR Topic objectives, and assess its feasibility. Develop the initial paper design and simulation prototype that demonstrate autonomous data mining across multiple modalities of data. A proof of concept is required to demonstrate feasibility of approach.

PHASE II: Develop the required technologies and prototype demonstration per the Phase I design. Develop and demonstrate simulation/emulation prototype tools and techniques for distributed data mining and autonomous operations for example but not limited to monitoring activities, anticipating behaviors, and discovering trends of entities or objects using performer generated real-world and/or synthesized data. A working large-scale simulation/emulation prototype is required where upon increased scaling the prototype demonstrates increases in its complexity and autonomy.

DUAL USE COMMERCIALIZATION POTENTIAL:
MILITARY APPLICATION: The resulting technology will deliver a scalable software tool able to fulfill a wide range of DoD needs for autonomous system operations. For example, such a system could continuously monitor information from various sources for situation awareness, perform information dissemination in denied environments, and increase the robustness of decision-making.

COMMERCIAL APPLICATION: Applications in the business intelligence, persistent surveillance, automation, data and trend analysis areas for example continuously monitoring information from various sources, performing background screening, and enabling autonomous decisions and analysis.

REFERENCES:
1. Dr. Werner J.A. Dahm, chief scientist, U.S. Air Force, “Technology Horizons: A Vision for Air Force Science & Technology During 2010-2030,” Vol. 1, AF/ST-TR-10-01-PR, 15 May 2010.

2. R. Pino, G. Genello, M. Bishop, M. Moore, R. Linderman, “Emerging Neuromorphic Computing Architectures & Enabling Hardware for Cognitive Information Processing Applications,” The 2nd International Workshop on Cognitive information Processing, CIP 2010, Elba Island, Italy, June 14-16, 2010.

3. James A. Anderson, “An Introduction to Neural Networks,” 1st Ed, MIT Press, New York, 1995.

4. Michael A. Arbib , “Handbook of Brain Theory and Neural Networks,” MIT Press, New York, 1998.

5. Robert Hecht-Nielsen, “Confabulation Theory: The Mechanism of Thought,” Springer, New York, 2007.

KEYWORDS: COMPUTATIONAL INTELLIGENCE, CLASSIFICATION, MULTI-AGENT SYSTEMS

OSD12-EP3 TITLE: Energy Storage Enclosure Technologies for High Density Devices

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Electronics

OBJECTIVE: Develop shock, vibration, environmental and EMI-hardened energy storage enclosures that are optimized to withstand and withhold/direct the energetics of a component or cascade of energy storage component failures. To provide this enclosure and protection of nearby personnel and equipment via state of the art materials and structural design so that the volumetric and gravimetric penalty is minimized.

DESCRIPTION: Energy storage systems, comprised of high-density batteries, capacitors (including electrolytic and asymmetric types) and/or flywheel technologies offer the potential for numerous benefits as applied to power systems of different types. However, high density storage systems, which may present electrical, chemical and inertial hazards must be able to be simply and effectively installed in locations which can be populated by personnel and sensitive equipment. Because of this, robust and rugged enclosures must be designed that are capable of overcoming effects related to temperature, pressure and inertial effects, at the same time. However, the approaches must provide substantial innovation because the effects upon size and weight due the enclosure and containment cannot substantially adversely affect the power and energy density of the storage systems.

Innovative R&D to support the creation of compact, lightweight, and high performance enclosure structures should support the evaluation of means of enclosing and isolating energy storage systems from the surrounding environment. The overall structural approaches should be scalable so that it may be applied to small, trailer mounted systems through large shipboard-mounted systems. Approaches must be considerate of the conditions of release, including MW thermal flux from failed components, overpressures in excess of 30 psig and inertial effects of rotating machinery containing in excess of 300 MJ and 100k RPM. If necessary, the system may provide a directed ventilation approach to allow gasses generated to escape into a specific, acceptable location or direction. The enclosure shall not require substantial volume above that already taken by the storage system itself, thus an enclosure system will not expand the volume more than 10% of the racked storage components. Ultimately the design should ensure strength of the shelving, resilience to gyroscopic effects of rotating machines, and resilience to shock, vibration and environmental effects as defined in the MIL specifications (Refs. 4,5,6). Any design should be able to support devices enclosed with voltages up to 1000VDC (including arcs and plasmas) and power capabilities up to 1MW, and provide penetrations to allow cabling sufficient for moving energy in and out of the enclosure. Cooling may also be assumed to be available, but no colder than 40 degrees Celsius at a flow rate proportional to the volume of the box. It should not be assumed that copious quantities of cooling liquid are available to cool the enclosure itself, but rather the items placed inside. However, small amounts could be utilized by the enclosure itself to support internal environmental characteristics. Aspects of packaging of components internal to the enclosure could be manipulated to support the overall requirements of the enclosure system; however the design must be flexible and adaptable to specific components or combinations of components inside.

PHASE I: The offeror will perform advanced modeling and analysis to evaluate the energetic characteristics of cascading chemical and inertial failure conditions, where it is assumed that a device fails on the order of one per minute continuously. The basis of the analysis will utilize the thermal and inertial metrics described above. The evaluations will be utilized to determine the requirements for scalable architectures which create minimal impact on device density. Utilizing this information, a conceptual design will be provided with traceable simulation basis to demonstrate performance. If possible, validation of simulated performance parameters will be provided prior to the option phase.

PHASE II: The offeror will scale the conceptual enclosure design to relevant size, which provides dense rack-mount capability and serviceability aspects. All input and output interface points will be defined and performance simulations evaluated with a greater level of detail. Equipment will be built to the designs produced, and validation of the performance aspects (inertial, mechanical, thermal, chemical resilience) will be demonstrated.

PHASE III DUAL USE COMMERCIALIZATION: Design and build a full-scale flexible rack-mount enclosure system for a particular military application, meeting appropriate MIL-SPEC operational requirements. A scalable, cost-effective enclosure scheme that provides local isolation from energetic release will enable lighter, more compact energy storage to be implemented onto a greater number of platforms and operational equipment.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology can be utilized anyplace that energy storage requires compact packaging and close collocation with other equipment or manned spaces.

REFERENCES:
1. Michalczyk, P.; Friel, C.; Vincent, C.; Marret, J.P.; Mexmain, J.M.; de Cervens, D.R.; Pere, P.; "Failure mode analysis on capacitor energy banks," Pulsed Power Conference, 2003. Digest of Technical Papers. PPC-2003. 14th IEEE International, vol.1, pp. 526- 529 Vol.1, 15-18 June 2003

2. Ma, Y. and Teng, H., "Comparative Study of Thermal Characteristics of Lithium-ion Batteries for Vehicle Applications," SAE Technical Paper 2011-01-0668, 2011, doi:10.4271/2011-01-0668.

3. Clint Winchester and Dave Kierin,"Lithium Batteries: Good Batteries Gone Bad", Joint Service Power Expo, May 2005. http://proceedings.ndia.org/5670/Lithium_Battery-Winchester.pdf

4. MIL-S-901D, resilience to shock.

5. MIL-STD-167-1A, vibration.

6. MIL-STD-810G, environmental effects.

KEYWORDS: Containment; Energy Storage, Damage

OSD12-EP4 TITLE: Tactical Power Plant Multi-Generator Intelligent Power Management Controller

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop and demonstrate a ruggedized tactical power plant generator controller to enable fuel savings and reduced generator wear.

DESCRIPTION: Tactical power generation for Army deployments has demonstrated low efficiency conversion due to wide variations in load. Tactical generators routinely operate below 50% of peak power which results in low fuel efficiency. Future endeavors and deployments will require the need to operate with fuel saving technologies to reduce the logistical footprint but maintain mobility and flexibility.

Generator right sizing operational analysis has shown the potential to provide the desired fuel savings and maintenance reduction while keeping a flexible, mobile overall force capability. This mode of operations involves only keeping a single generator online, up to the rated power output, to match the continuous electrical load requirement. As the continuous electrical load is increased, additional generators can be brought on line or larger single generator operations can occur. Energy storage is utilized to deal with peak loads beyond generator rating or transition to the higher continuous operational load. Fuel savings >25% are anticipated for operations in this condition. Additional supplemental incorporation of baseload renewable power can increase overall fuel savings potential beyond this.

It is desired therefore to develop a tactical generator intelligent manager to enable right size operations on existing Army assets. This unit, developed under this effort, will be a form, fit, and function replacement of the existing switchbox on the AN/MJQ-18 10kW Power Plant with the development controls functionality for generator right sizing operation incorporated into it. The control unit will also maintain the capability of the existing switchbox and be environmentally hardened to handle military environments. All generator right sizing operation events will be automatic with no intervention from an operator. The system shall utilize the recently developed AMMPS 10 kW tactical generator with necessary modifications as well as energy storage and optional 3kW renewable source input. Proposals are encouraged to include generator dispatch strategies and intelligent power management concepts which emphasize the ability to manage fuel savings and generator life. The load profiles are undefined and can range from steady state loads to high peak loads.

PHASE I: Develop a conceptual design for intelligent power manager controller for right size operations which will control the operation of, and synchronize power of two 10 kW generators on the AN/MJQ-18 Power Plant, an energy storage device, and an additional DC input from a 3 kW DC renewable source. The unit shall additionally be a form, fit and function replacement of the switchbox on the AN/MJQ-18 10kW Power Plant. The generator control system shall employ an intelligent power management approach which utilizes current operating conditions and intelligent dispatch strategies to manage generator operations for overall fuel savings and generator wear reduction. In addition, the unit shall have flexibility to operate with multiple communication protocols, as defined by the Army, for control of the generator units and receipt of load information from the electrical bus.

PHASE II: Develop a dynamic model of the enabling capability to show how power quality is met during generator transitions. Develop and demonstrate a full scale ruggedized generator control unit to meet the needs identified in Phase I. Conduct a proof of concept demonstration to show feasibility of operation and highlight benefits of generator right size operations utilizing the latest Army communication protocols for load and unit control.

PHASE III DUAL USE COMMERCIALIZATION: Update the detailed design of the generator controller for a complete power unit, incorporating the technology previously developed in Phase II. Build final design unit and conduct mil-spec testing to certify for military use with a provided energy storage unit. The unit will be delivered to a military facility for demonstration testing in a relevant environment.

REFERENCES:
1. MIL-HDBK-633F, Standard Family of Mobile Electric Power Generating Sources

2. Technical Manual TM5-6115-633-14&P, Power Plant AN / MJQ - 1 8 (2) MEP - 003 A 10 KW 60 HZ Generator Sets M103A3 2-WHEEL, 1 1/2 TON Modified Trailer

3. MIL-STD 1332, Definitions of Tactical, Prime, Precise, and Utility Technologies for Classification of the DoD Mobile Electric Power Engine Generator Set Family

4. MIL-STD 810: Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

5. Army Regulation 70-38, Research, Development, Test and Evaluation of Material For Extreme Climatic Conditions

6. Fuel curves for SBIR Topic OSD12-EP4, uploaded in SITIS 9/4/12.

7. Schematic diagram of switchbox for SBIR Topic OSD12-EP4, uploaded in SITIS 9/4/12.

6. [Deleted 9/14/12.]

7. [Deleted 9/14/12; see new Refs. 8, 9, 10]

8. Drawing 13230E6535, Switch Box Assembly, 5 and 10 kW TQG, uploaded in SITIS 9/14/12.

9. Drawing 13230E6536, Switch Box Enclosure drawing for the 5 and 10 kW TQG, uploaded in SITIS 9/14/12.

10. Drawing 13230E6537, Switch Box Cover drawing for the 5 and 10 kW TQG, uploaded in SITIS 9/14/12.

11. Technical Manual: TM9-6115-660-13&P (page 163 and Fold Out #2), uploaded in SITIS 9/14/12.

KEYWORDS: Generators, Energy Storage, Controller

OSD12-EP5 TITLE: Dynamic Time and Frequency Domain Modeling of Aircraft Power System with Electrical Accumulator Units (EAU)

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Human Systems

OBJECTIVE: Develop generic time and frequency domain analysis modeling and analysis tools to analyze and determine mitigation strategies to maintain power quality with high dynamic aircraft power systems operating with electrical accumulator units (EAU).

DESCRIPTION: Ever increasing high dynamic load demands are being placed on aircraft power systems. Peak and regenerated energy demands for electrical actuation and the power and thermal management system (PTMS), electrical starting demands, and emergency power demands stress the capability of the power system to maintain power quality under all operating conditions. In order to meet these varied and complex load characteristics, mitigation strategies are required that involve energy storage and filtration for any unwanted generated distortions. However, aircraft designs remain sensitive to overall size and weight for such installations. In addition to these constraints, current options for analysis are limited in their fidelity and ability to properly examine these high transient conditions to understand how various energy storage and other devices will interact with the system and how reliably any chosen devices will perform.

Therefore, a tool to facilitate dynamic time domain analysis and frequency domain analysis is desired to examine devices used to meet load requirements. During usage, the tool should have the capability to insert generic aircraft power system models including the electrical accumulator units and energy storage to perform analysis. The subsystem used for this study should be able to source a minimum of 150kW for 100ms of peak power and sink at least 150kW for 50ms of regenerated energy. In addition, the unit must adhere to, or, upon maturity, demonstrate the ability to meet MIL-STD-704F Aircraft Electric Power Characteristics. Since the available data for analysis is typically owned by the system manufacturers, small businesses wishing to pursue this topic will most likely need to partner with a large OEM.

PHASE I: Develop and demonstrate concept for a dynamic time domain and frequency domain analysis tool utilizing provided aircraft operating data and models.

PHASE II: Improve models as necessary to improve fidelity to identify capabilities, methodologies technologies to further improve overall power quality on aircraft power systems. Develop improved mitigation components and methodologies. Validate in a simulated power system bus incorporating signals for high demand loads, sources, and energy storage.

PHASE III: Validate full scale mitigation technologies in hardware in the loop ground demonstrations for future aircraft.

DUAL USE COMMERCIALIZATION: Military Application: F-35 and most UAV's employ electric actuation to critical flight surfaces. A measure of aircraft power system power quality is most important for these applications. Commercial Application: Emerging commercial airliners are employing utilities that are electrically driven.

REFERENCES:
1. Moir, I., and Seabridge, A., "Aircraft Systems: "Mechanical, electrical, and avionics subsystems integration," ISBN:978-0-470-05996-8. 2. Archived FedBizOps information: http://www.fbodaily.com/archive/2008/06-June/22-Jun-2008/FBO-01598541.htm

2. MIL-STD-704F, Aircraft Electric Power Characteristics

KEYWORDS: Modeling, Energy Storage, Aircraft

OSD12-EP6 TITLE: <u>Cylindrical Geometry Energy Storage Cooling Architectures</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To develop compact, low thermal resistance solutions for maintaining the temperature of cylindrical energy storage components set up in high voltage arrays. Better temperature control in platforms will reduce the need to de-rate components, improving reliability and system energy density.

DESCRIPTION: Future military platforms will require more extensive use of electronic power systems to achieve required performance levels. Energy storage is becoming a key enabler for power systems operating with high levels of transient power requirements and supporting fuel-efficiency operations while maintaining capability. High density energy storage which operates continuously at high charge and discharge rates to support these loads under the combination of finite space, high power and energy requirements, stringent safety characteristics and wide upper temperature ranges drive the requirement for advanced cooling systems. Proper thermal management of these high power electronic systems becomes more difficult as increasing power density requirements push heat generating components closer together. This is made more severe due to relatively low full power operating temperature limits (in the range of 55-60C for certain components) which force designers to de-rate the components to ensure reliable operation. The combination of close proximity, volumetric self-heating, and platform coolant temperatures as high as 50C all contribute to increased system volume from redundant storage arrays operating with reduced energy density. While ongoing research efforts are attempting to develop components with higher operating temperature limits, improved methods of efficiently managing the thermal aspects of batteries, capacitors and flywheel motor/generators provides a near-term reduction in the need for component de-rating which would reduce component redundancy and increase system power density. Storage devices with a cylindrical, can-style structure cannot efficiently couple to the high performance cold plates and heat sinks being implemented to cool other components. Although air-cooling methods (including finned adapters, etc.) have been utilized in the past, system volume constraints and platform placement typically remove useful convective flow paths. Other proposed techniques for thermal coupling have included the use of inefficient thermal interface materials, thermal conduction through the electrical terminals, or significant modifications, none of which provide a cost and performance effective solution.

Innovative R&D is needed to investigate cooling architectures which can be enabled for cylindrical geometry energy storage components that must be integrated into larger arrays. The technologies should be scalable from small 18mm type cells through motors of 100mm or greater diameter. The cooling architectures should be able to space-efficiently couple to a backplane, being integrated into shelving or cabinet designs to help maintain climate or thermal isolation and regulation throughout the device.

The innovative products brought forth through this SBIR effort should not contain precious or hazardous materials, nor require significant interfaces in order to support. It is optimal for these devices to operate such that chilled water is not required, though fresh and/or seawater can be assumed to be available at 40C, with sufficient flow available to meet mission needs. Ambient spaces should be assumed to be up to 60C and worst-case device maximum temperatures should also be assumed to be 60C. In order to maintain density of the energy storage devices, these cooling structures should not expand the individual components greater than 10%, yet be capable of supporting pressure both from the inside in the form of cooling fluid flow, as well as external under compression of a battery pack, expansion during cycling operation, etc. If a special cooling fluid is to be utilized, the interface to facility/platform cooling fluid should be considered, along with the impact on efficiency and device/system density and packing factor.

PHASE I: The offeror will determine the feasibility of cooling devices through advanced architectures which are scalable and create minimal impact on device density. Proof of concept will be shown on a synthetic scale via modeling and simulation with comparison against current methods. Demonstration of the proof of concept will indicate maintenance of temperatures in a cylindrical geometry with resistive heaters as a source. The proof of concept should also be demonstrated on operating storage devices to compare to control of the same design. This should be a high power operation, with all safety considered as part of the determination of size.

PHASE II: The offeror will scale-up the cooling in applicable geometries for arrays of cylindrical devices operating together with a minimum individual component diameter of 26mm. For batteries or super-capacitors, the design should be strings no less than 48VDC. Evaluate the performance and limitations of the prototype for a range of coolant temperatures and internal/external thermal conditions. Validate through modeling or demonstration the ability to transition the solution for specific military applications and characterize any array dependent size/performance trade-offs inherent in the solution.

PHASE III: Design and develop a modular cylindrical structured cooling mechanism for a particular military application, meeting appropriate MIL-SPEC operational requirements. Continued commercial investment in hybrid ground and air vehicles will increase the demand for larger power conversion systems. A scalable, cost-effective capacitor cooling scheme will enable lighter, more compact electronics solutions to reach the commercial market.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology can be utilized by the mobile construction industry to save fuel costs and reduce emissions. State and local governments could also benefit from this technology for various applications.

REFERENCES:
1. Buford, K., Williams, J., and Simonini, M., "Determining Most Energy Efficient Cooling Control Strategy of a Rechargeable Energy Storage System," SAE Technical Paper 2011-01-0893, 2011, doi:10.4271/2011-01-0893

2. Ma, Y. and Teng, H., "Comparative Study of Thermal Characteristics of Lithium-ion Batteries for Vehicle Applications," SAE Technical Paper 2011-01-0668, 2011, doi:10.4271/2011-01-0668.

3. Bernardes, J. S.; Sturmborg, M. F.; Jean, T. E., "Analysis of a Capacitor-Based Pulsed-Power System for Driving Long-Range EM Guns", Magnetics, IEEE Transactions on, Volume: 39, Issue: 1, Jan. 2003 Pages: 486-490.

KEYWORDS: Thermal Management; Energy Storage, Heat Exchanger

OSD12-EP7 TITLE: Militarized Power Line Communication

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics

OBJECTIVE: Demonstrate cost effective, secure, militarized power line communication system components which can provide a reduced infrastructure solution to properly manage variable resources and loads for multi generator operations, bases, and platforms.

DESCRIPTION: Communication is the key to successfully managing the elements that make up a smart electrical architecture or grid including components such as generators and energy storage. The communication system should provide real time determination of operational allocation as well as individual asset state of health. An optimized communication system can also seamlessly integrate renewable power sources that can be distributed throughout the base even if portions of the micro-grid are damaged. Smart micro-grid management and power source distribution decreases the likelihood that critical mission activities could be without power. However, the overall complexity, cost, and time associated with installation, maintenance, and operation of current communication options such as fiber optic or coaxial cable can be excessive. These current methods require installing a dedicated communication cable or using a wireless system. However, the wireless system could potentially interfere with other RF (Radio Frequency) systems.

The method under this effort would use power cables as the communications backbone thus reducing the cost of installation, maintenance and interference with operations during installation. This method would also reduce the cost of running a dedicated fiber or coaxial line throughout the installation to handle the communications function as well as significantly reducing install and setup times. The technology gap between commercial state-of-the-art devices capable of sending information over the power cable and the type of device necessary to intelligently manage a smart micro-grid for cost effective military purposes is desired. This effort is designed to bridge that gap with a combination of affordable modified devices capable of sending and receiving data over the power line including power sensors, power electronics, smart power distribution hardware, etc.

PHASE I: Provide a conceptual design of a power line communication system to properly manage a smart electrical grid utilizing multiple generator sets, energy storage, operating on a 208VAC, 3phase electrical bus. This conceptual design should account for proper communication protocol and latency, security of operation from outside sources, security of operation and power quality from interference derived from grid operation resources and loads. In addition, consideration should be given to characterization of the communication channel, modulation techniques, and considerations for noise on the channel. Emphasis should be given for ease of installation, operation, maintainability, and cost effectiveness of components including devices capable of sending and receiving data over the power line including power sensors, power electronics, smart power distribution hardware, etc in a military environment. Provide a conceptual design of individual militarized critical components as required.

PHASE II: Provide a detailed design of critical cost effective military power line communication components. Perform a scaled demonstration of critical components utilizing PLC to prove feasibility of qualities outlined in Phase I description.

PHASE III DUAL USE COMMERCIALIZATION: Pursue dual-use of the developed hardware solution. There are three areas where the technology development in this SBIR proposal could prove dual-use.

REFERENCES:
1. K Dostert, 1997, Telecommunications over the Power Distribution Grid- Possibilities and Limitations Proc 1997 Internat. Symp. on Power Line Comms and its Applications pp 1-9

2. MIL-STD 1332, Definitions of Tactical, Prime, Precise, and Utility Technologies for Classification of the DoD Mobile Electric Power Engine Generator Set Family

3. MIL-STD 810, Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

4. MIL-STD-461, Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

5. MIL-STD-462, Test Method Standards for Measurement of Electromagnetic Interference Characteristics

KEYWORDS: Power distribution, communications

OSD12-ER1 TITLE: Evaluating Component Interactions Within Complex Systems

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Human Systems

OBJECTIVE: Develop a human-in-the-loop software tool for visualizing the interaction between components and subsystems in a complex system design process. Visualization of design workflows will decrease the risk of unanticipated interaction effects by informing the user of the nature and importance of intra-system interactions at various levels of abstraction. The tool must provide quantitative data to supplement the visualization in a format that is customizable by the user depending on their goals. One goal is to reduce workflows subject to time and cost bounds while providing live updates on the changing nature of sub-system and component interaction. Another goal is to ensure executability of workflows from multiple tools or databases that use differing schemata, hierarchies, and attributes. A far-term goal would be intermediating between outputs of workflow elements and inputs of their successor elements to ensure their compatibility, which could be possible once a tool has been sufficiently developed for a particular application.

DESCRIPTION: The Department of Defense (DoD) must be prepared to support a wide range of missions across dynamic and uncertain futures, including rapid changes in missions, threats, and operating environments. This requires efficiently creating, fielding, and evolving trusted defense systems that can proactively meet these needs. A key goal is ensuring that engineering programs maximize utility and represent best value for the investment across a breadth of potential missions in joint operational environments. Design, analysis, and assessment of multiple alternatives to achieve this goal requires that internal and external interactions with the design solution be well understood, and implications of both design and usage choices be communicated to the decision maker. Therefore, new methods and tools are needed that compensate and recover from disruptions, adapt to dynamic environments, and rapidly deliver new solutions.

In a non-complex system, component and subsystem models are well-defined and the nature of their interactions is predictable. The challenges of concern to the government are in engineering of very complex systems such as advanced weapons, aircraft, vessels, and vehicles with interacting cyber-electrical-mechanical-material solutions to multiple requirements. Such complex systems are dynamic, have a greater likelihood of interactions between components, have non-linear responses, are sensitive to initial conditions, learn and adopt behaviors such that they are not predictable, and exhibit interactions amongst components that are not governed by well-defined rules. Adding new capabilities in one domain invariably leads to detrimental impacts in others (e.g., faster processors or improved self diagnostics may increase power consumption and consequently reduce lifetime). As a result, knowledge of individual components in a complex system reveals little to nothing about system behavior. This makes overall behavior difficult to accurately model. Systems must be designed together with components in multiple contexts of realistic usage conditions to achieve a more realistic understanding of the overall system behavior.

For example, current approaches to prognostic health monitoring may use Bayesian statistics to determine the most probable root cause of failure given current operating conditions, or use fault tree analysis and probabilistic risk assessment to understand the probability of a fault occurring and the severity of its outcome. However, interactions within complex systems must be understood much earlier, during the design phase, in order to reduce the risks of unanticipated interactions. These interactions, and their dynamic consequences, are not intuitively identifiable. Although designers of complex systems know that “everything affects everything else”, they are currently unable to establish design-level diagnostics that can analyze, test, and evaluate such interactions.

To accomplish the objectives as outlined, three major steps are required. First, a decomposition of the system into the relevant subsystems and components is required. Next, the interdependence and importance of each subsystem relative to the others must be understood. The Analytic Hierarchy Process and IDEF0 are examples of tools which enable functional decomposition of complex systems, although they are not the only tools available for this purpose, and exploration of options is encouraged at this stage. Third, a graphical representation of the interdependence of the subsystems and components is required. One tool in common usage by the decision theory field is the influence diagram, however there are plenty of other options available for this purpose as well. Lastly, the integration or overlay of quantitative information to supplement the information provided by the graphical representation will complete the tool. Key capabilities will be adjustability of the level of abstraction (i.e. sub-system, component) and a graphical user interface that enables the user to make adjustments to the graphics and data displayed in the visualization tool.

PHASE I: Phase I is expected to first identify an existing complex system that has known interactions and corresponding consequences. The offeror will then develop a tool that captures these interactions such that human-guided sets of design analysis, testing, and evaluation workflows are generated, and results checked against the known behavior of the system.

PHASE II: Phase II is expected to expand the tool from Phase I to be applied to the existing complex system in order to automatically generate the interacting workflows. It is expected that important interactions will not simply be duplicated, but rather identified solely through the automatically generated workflows.

PHASE III: Phase III is expected to allocate the automatically generated reduced workflow sets to tools that use differing schemata, hierarchies, and attributes, which will then execute the individual workflow elements and automatically identify, analyze, and evaluate interactions. Further, the tool from Phases I and II will be applied to a complex system with either poorly defined, or undefined, interactions and their corresponding consequences to test the application of the SBIR solution.

REFERENCES:
1. Saaty, T., The Analytic Hierarchy Process. 1980, New York, McGraw-Hill.

2. http://www.idef.com/idef0.htm

3. Howard, R. A., and J. E. Matheson. 1981. Influence diagrams. In Readings on the Principles and Applications of Decision Analysis. Ed., R. A. Howard and J. E. Matheson. Vol. II (1984). Menlo Park, Calif.: Strategic Decisions Group, pp.719-762.

4. Systems-2020 Study; Final Report. Booz Allen Hamilton, August 2010.

5. Whitney, Daniel E., Physical Limits to Modularity. March 2004.

6. NSF and NASA Workshop on Large-Scale Complex Engineered Systems: From Basic Research through Product Realization, Arlington, VA February 7-9, 2012.

KEYWORDS: complex, system, interaction, workflow, database, communication, data, non-linear, behavior

OSD12-ER2 TITLE: Functional Allocation Trades Between Hardware and Software

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics

OBJECTIVE: Develop a software tool for allocating system functions to implementations of hardware or software with the intent of quantitatively assessing the benefits and drawbacks (utility) of these allocation options from a hierarchically increasing view (component, subsystem, system, system-of-systems). The software tool shall make comparative assessments between allocations of the same function to hardware and software implementations by presenting the decision maker with a qualitative (graphical) and quantitative overview of the impact of the chosen allocation in a dashboard format.

DESCRIPTION: The Department of Defense (DoD) must be prepared to support a wide range of missions across dynamic and uncertain futures, including rapid changes in missions, threats, and operating environments. This requires efficiently creating, fielding, and evolving trusted defense systems that can proactively meet these needs. A key goal is ensuring that engineering programs maximize utility and represent best value for the investment across a breadth of potential missions in joint operational environments. Design, analysis, and assessment of multiple alternatives to achieve this goal requires that internal and external interactions with the design solution be well understood, and implications of both design and usage choices be communicated to the decision maker. Therefore, new methods and tools are needed that compensate and recover from disruptions, adapt to dynamic environments, and rapidly deliver new solutions.

System lifecycle cost, reliability, availability, and other measures for assessing the effectiveness of a system are iteratively and recursively constructed from the component level up to the system or system of system level. When functions are decomposed and allocated at each hierarchical level, system designers need to decide whether a function is better met through an implementation of hardware or software. The impacts of these decisions need to be understood earlier in the design process in order to limit or eliminate delays and non-compliances of the system.

Traditional values associated with software include increased execution speed and scalability, while hardware is associated with integration, testability, modularity, and lower cost. With the expanding role of software in achieving system functionality, the aforementioned values are no longer binned into either implementation. The result is the ability to more evenly trade the implementation of hardware or software.

Current methods of functional and physical allocation result in design processes in which requirements are decomposed into and satisfied by functions, and functions are allocated to physical components. However, this approach does not satisfy the need to perform quantitative trade studies between alternative decompositions of functions, and alternative assignments of those functions to hardware and software. For example, during this allocation phase of design engineering, should a high sea state small aircraft landing requirement be met through advanced avionics and control logic coupled to delicate landing gear, vs. more basic control logic coupled to ruggedized landing gear; vs. some intermediate combination of these hardware and software solutions? Such decisions have proved, time and time again, to have tremendous impacts on the cost, development time, reliability, and even ultimate feasibility of Defense systems. New methods and tools are needed to perform early, informed trades between the allocation of functions to hardware or software, such that the system-level impacts of these decisions can be quantified and communicated.

Successful completion of the objectives described will require a few key aspects to be addressed. First, a software tool must be developed that enables the user to select from a variety of potential hardware and software subsystems in a bottom-up or top-down style. This means that given a set of desired system functions, the user will be able to specify the desired composition of subsystems individually, or the user will be able to request a particular ratio of hardware and software systems, with the tool selecting the subsystems required to meet this constraint and maximize system utility. Second, the tool must enable the user to enter a variety of relevant information about each subsystem or component, thus allowing for generality in the usage of the tool. With this information, the tool shall compute the expected utility of the chosen composition of subsystems or components. Third, the tool shall present to the user a variety of graphical and numerical data that informs their decision, enables sensitivity analysis, presents the interdependencies of the subsystems, and aggregates the information in a graphical display supplemented by numerical data that may be manipulated and explored by the user.

PHASE I: Develop approaches for manually (bottom-up) and automatically (top-down) allocating functions, at varying levels of the system hierarchy, to hardware and software alternatives and determining the optimal implementation allocation approach based on a set of quantitative measures of benefits and drawbacks (reliability, safety, function execution speed, reusability, lifecycle cost, etc.).

PHASE II: Produce a working software tool for the allocation and assessment environment at the component and subsystem level. The selected measures of utility will be quantified, baselined, and compared for various combinations of hardware and software selections.

PHASE III: Produce an expanded capability, demonstrating the applicability of the method, and human-aided allocation selections and assessments, up to the system-of-system level. The maturity of the software tool should be advanced to a point that is sufficient to enable detailed understanding of the decision and a variety of data visualization and manipulation tools should be available to the user to further their understanding of the allocation they are making.

REFERENCES:
1. INCOSE Systems Engineering Handbook, v3.2.2. INCOSE-TP-2003-002-03.2.2. October 2011.

2. Banta, Gary. “The Changing Role of Software as Hardware”, Embedded Systems Programming, September 2005.

3. “Streamlining Chip Design”: http://web.mit.edu/newsoffice/2011/streamlining-chip-design-1208.html.

4. Removed 8/21/12.

5. Engler, William O., Patrick T. Biltgen, and Dimitri N. Mavris. "Concept Selection Using an Interactive Reconfigurable Matrix of Alternatives (IRMA)". 45th AIAA Aerospace Sciences Meeting and Exhibit, 2007. (AIAA 2007-1194)

KEYWORDS: Keywords: allocate, function, hardware, software, reliability, safety, trades, benefit, lifecycle, cost

OSD12-HS1 TITLE: Human Computer Interfaces for supervisory control of Multi-mission, Multi-Agent Autonomy

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate novel decision support concepts and supporting Human Computer Interfaces (HCI) for the supervisory control of multiple autonomous vehicle systems, concurrently engaged across multiple missions.

DESCRIPTION: The man-machine interfaces for the next generation of unmanned platforms for Navy missions must be capable of managing highly autonomous systems with a supervisory control concept of operations. These new interfaces will require underlying reasoning engines that enable management of vehicles/systems in terms of mission goals and objectives. As described in [1], achieving fully autonomous systems will require the operators and the system to transact mission critical information on the basis of goals and translate them into a series of tasks to be performed without extensive human interaction. Mission tasks may need to be revised over the course of a mission as a function of unanticipated mission events, or emergent mission needs. These systems will have high levels of autonomy that operate through a sophisticated supervisory control model. This topic is intended to develop innovative solutions to address the unique requirements of operating highly autonomous systems. This need is critical due to the urgent need to move to a single controller being able to monitor and control multiple unmanned systems and performing across domains working as a collaborating team with the autonomous system, as documented in numerous Department of Defense objectives [2].

The current state-of-the-art in autonomy mission management technology is limited. Current HCI does not allow operators to transact on the basis of goals, nor do they provide the capability to adapt goals without significant offboard (human) mission planning. The next generation of autonomous systems will require the management of multiple goals arising from a rapidly changing situation on the ground. An HCI design for managing autonomous systems on the basis of goals is required for the autonomous systems of the future. Methods and algorithms are required to enable an efficient interface of mission goals and tasks for the management of multiple software agents or platforms. This will provide the human planner the flexibility to redirect the platform and reduce the number of specialized operators needed for platform management based on high level goals. In particular, methods are required for mixed-initiative goal formulation, goal prioritization, goal retraction and goal-based agent autonomy.

The desired interface research should address a modular architecture that describes: 1) Reasoning approaches for mixed initiative goal management in multiple and concurrent,(but potentially related), missions; 2) An ontology for mission types, tasks, and plans with approaches for integration to the efficient display and manipulation of mission essential tasks; 3) A notional ontology for autonomous platforms capabilities and capacities; and 4) Knowledge authoring tools for autonomy management knowledge bases (e.g., the ontologies themselves).

PHASE I: Develop a conceptual design that considers appropriate human factors design principles in providing an intuitive interface for managing mission goals in real-time to enable the user to rapidly adapt to changes in mission context. Interfaces for autonomous platforms are generally geared toward the engineer who has great insight into how the systems works, and not the operator who may be focused on meeting mission objective and may not care how the internal system works [3]. This design specification must address functionality from the perspective of a human supervisory controller; should include a workflow that is able to recommend sequences of goals that should be pursued to meet mission requirements; and metrics to assess the improvement in overall system performance against a baseline capability.

PHASE II: Develop a detailed design and implement an initial prototype of the autonomy management platform. Demonstrate the effectiveness of autonomy management in multi-mission operations and/or adversarial environment. Derive and empirically demonstrate improved operator responsiveness to real-time changes in mission execution and/or changes in goals. This phase should involve: a description or specification for how the technology would integrate with an actual autonomous platform and rationale for selection; documentation of the Concept of Operations for representative sets of missions; and data collection and analysis techniques to support the evaluation of metrics defined in Phase 1.

PHASE III (PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL USE APPLICATION): Refine the prototype and make the feature set complete in preparation for transition into the Navy. In addition to the Department of Defense, there will be a considerable demand for managing goals associated with autonomous systems in the commercial sector, federal and state agencies such as law enforcement and emergency management. For example, research and development in the field of robotics in the entertainment industry and home service industry can benefit from goal management techniques. At the state level, local police agencies now use lightweight unmanned systems to support surveillance, and as these systems become more complex and gain wide spread use, the ability to manage goals for different law enforcement missions will be required.

REFERENCES:
1. Department of Defense. (2011). Unmanned Systems Integrated Roadmap FY2011-2036.

2. Lee, J.D., & See, K.A. (2004). Trust in automation: designing for appropriate reliance. Human Factors, 46, 50-80.

3. Meyer, J. (2001). Effects of warning validity and proximity on responses to warnings. Human Factors, 43, 563-572.

4. Meyer, J. (2004). Conceptual issues in the study of dynamic hazard warnings. Human Factors, 46, 196-204.P

5. Parasuraman, R., & Riley, V. (1997). Humans and Automation: Use, Misuse, Disuse, Abuse. Human Factors, 39, 230-253.

6. Cummings, M.L. (2004). Automation bias in intelligent time critical decision support systems. Paper presented at the AIAA 3rd Intelligent Systems Conference, Chicago.

KEYWORDS: Anomaly Detection, Supervisory Control, Autonomous Systems, Decision Support, Behavioral Modeling, Representation of Goal Directed Behavior, System Management, Human Computer Interaction

OSD12-HS2 TITLE: Naturalistic Operator Interface for Immersive Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate effective teleoperator interface methods for supervisory control of a network of assets in a fully-immersive, synthetically-augmented environment.

DESCRIPTION: Surveillance and intelligence gathering can be linked to finding needles in haystacks – it may take days or weeks to gather enough evidence in an operational environment to take decisive action. If non-cooperative subjects know they are under surveillance, enough evidence may never be aggregated; this is particularly true in urban environments where it is difficult to observe a scene without being noticed. To enable intelligence, surveillance, and reconnaissance (ISR) operations, smaller and stealthier sensors are currently being developed that will allow the operator to gather critical information remotely. This physical detachment from the combat arena requires revolutionary interface technologies to provide the operator with a sense of presence in the remote environment. Obtaining a sense of environmental presence is critical to the operator's decision-making ability, situation awareness, and workload.

In order to gain an authentic sense of environmental presence, research suggests that a fully-immersive, synthetically-augmented display system is ideal for contemporary sensor operations. An example of such a system is the Supervisory Control and Cognition Branch's (RHCI's) Immersive Collaborative Environment (ICEbox), which employs several large, high resolution displays, appropriately positioned to completely enclose the operator. In contrast to traditional sensor display systems, which consist primarily of an assemblage of several computer monitors, the fully-immersive characteristic of the ICEbox, as well as its ability to exhibit synthetically-augmented overlays, perceptually allows the operator to establish a sense of presence in the remote environment. It is believed that by developing a perceptual sense of environmental presence through an expansive field of view and data presentation the operator will experience an improvement in both decision-making and situation awareness, and a decrease in workload.

Despite the identified benefits related to remote interaction with a network of collected assets, employment of such a system has yet to come to fruition because the state of the art of fully-immersive, synthetically-augmented display technology suffers from a deficient means for human-machine interaction. The most significant challenge faced by researchers and designers is developing an innovative and effective human-machine interface that does not rely on the impractical (in this instance) use of a traditional keyboard and mouse. Ideally, since humans routinely exercise several sensory avenues simultaneously during information exchange, an intuitive human-machine interface would consent to the use of multiple modes of input concurrently. However, recent efforts at incorporating alternative modes of input (such as speech recognition, touch, full-body gesture recognition, eye-tracking, etc.), are commonly focused on the use of a single modality at the exclusion of others. Additionally, inaccuracies related to the recognition of user input, and the interpretation of user intent, continue to arise with each individual modality. Furthermore, for those few who have attempted to fuse simultaneous input from multiple modalities, the noted problematic occurrences are compounded by the complexity of the integration. As a result, the state of the art of fully-immersive, synthetically-augmented display technology is handicapped from progressing at a more accelerated rate.

If fully-immersive, synthetically-augmented display systems are to rapidly mature, a more robust and naturalistic means for human-machine interaction (HMI) must come to fruition. Creating HMI that realizes this "telepresence" and mission effectiveness simultaneously requires developing novel interface concepts, which in turn will distill requirements for sensor and information network responsiveness and control. Actualizing this capability by means of a human-centric approach should improve operator performance at both the individual and team levels.

PHASE I: For remote sensor network management, develop a framework that supports intuitive human-machine communication in a fully-immersive, synthetically-augmented environment. Demonstrate aspects of the constituent technology and illustrate how it will be incorporated to provide enhanced benefits in Phase II. Develop an experimental plan to establish improvements in usability in Phase II.

PHASE II: Develop and demonstrate a prototype system to be employed in a representative application domain simulation. Evaluate the human-machine exchanges to illustrate payoffs in interaction speed, error reduction, workload, training time reduction, and/or interaction flexibility.

PHASE III:
MILITARY APPLICATION: Successful maturation of intuitive human-machine interaction technology to be employed in a fully-immersive, synthetically-augmented environment would enhance a variety of complex military and commercial monitoring, planning, and control domains.

COMMERCIAL APPLICATION: Remote sensor operations and RPA control are immediate application areas, but utility would also be warranted in domains such as virtual learning environments, advanced business teleconferencing, and enhanced medical imaging systems.

REFERENCES:
1. Boussemart, Y., Rioux, F., Rudzicz, F., Wozniewski, M., and Cooperstock, J. (2004). A Framework for 3D Visualisation and Manipulation in an Immersive Space Using an Untethered Bimanual Gestural Interface. In Proceedings of the ACM Symposium on Virtual Reality Software and Technology, 162-165.

2. Gallo, L., Placitelli, A., and Ciampi, M. (2011). Controller-Free Exploration of Medical Image Data: Experiencing the Kinect. In Proceedings of the 24th IEEE International Symposium on Computer-Based Medical Systems,1-6.

3. Gross, M., et al. (2003). Blue-C: A Spatially Immersive Display and 3D Video Portal for Telepresence. In Proceedings of the Workshop on Virtual Environment, 22(3), 819-828.

4. Keefe, D., Feliz, D., Moscovich, T., Laidlaw, D., LaViola, J. (2001). CavePainting: A Fully Immersive 3D Artistic Medium and Immersive Experience. In Proceedings of ACM Symposium on Interactive 3D Graphics, 85-93.

5. Kehl, R., and Van Gool, L. (2004). Real-Time Pointing Gesture Recognition for an Immersive Environment. In Proceedings of the 6th International Conference on Automatic Face and Gesture Recognition, 577-582.

6. Rowe, A. J., Liggett, K. K., and Davis, J. E. (2009). Vigilant spirit control station: a research testbed for multi-UAS supervisory control interfaces. In Proceedings of the Fifteenth International Symposium on Aviation Psychology. Dayton, OH: WSU.

7. Tollmar, K. Demirdjian, D., and Darrell, T. (2003). Gesture + Play: Exploring Full Body Navigation for Virtual Environments. In Proceedings of Computer Vision and Pattern Recognition for Human Computer Interaction. Madison, WI.

8. Vigilant_Spirit_Control_Station_ISAP_2009_Final_with_PA_Number.docx (added by TPOC on 8/16/12).

9. ICEboxRoomDiagram.JPG (added by TPOC on 8/16/12).

10. ICEbox.pdf (added by TPOC on 8/16/12).

KEYWORDS: immersive interface, augmented reality, Xbox Kinect, intuitive gesturing, 3D gesturing, 3D audio, speech recognition, eye tracking

OSD12-HS3 TITLE: Natural Dialogue – based Gesture Recognition for Unmanned Aerial System Carrier Deck Operations

TECHNOLOGY AREAS: Air Platform, Human Systems

OBJECTIVE: The objective of this effort is to develop and demonstrate a minimally intrusive technology that supports gesture recognition for safe control of UASs on a carrier deck during flight operations.

DESCRIPTION: Future concepts of operations for Unmanned Aerial Systems (UAS) include a requirement for an aircraft carrier – based platform. A major challenge with basing UAS on aircraft carriers is integrating them into the flight operations launch and recovery cycle –the sortie rate. Currently, on a carrier deck, control of manned aircraft is achieved primarily through gestures presented to aviators by Sailors tasked with handling and directing aircraft. These personnel use a well-defined, and minimalist, set of gestures to guide aircraft through a range of deck-based maneuvers. The use of non-traditional commands- or non traditional approaches to deliver these commands- to maneuver UASs on the flight deck will introduce significant hurdles in terms of integrating UASs into flight operations and may significantly increase a carrier's sortie rate – a key readiness measure.

Recent advances in several technical domains provide a unique opportunity to develop the capability for UASs to recognize and act on the same kinds of gestures that are used to guide manned aircraft. These include: the ability to support human gesture recognition without requiring the user to wear special equipment [1]; The development of knowledge structures to provide a formal approach for representing and characterizing underlying behaviors [2,3]; and, advances in developing systems that can communicate naturally with human users [4]. Along with other technologies, these advances provide the necessary framework for providing carrier-based UAS platforms with the capability to recognize the same – or similar- set of gestures used to guide manned aircraft around the flight deck safely and effectively.

This topic is requesting proposals for developing Natural Dialogue – based Gesture Recognition for Unmanned Aerial System Carrier Deck Operations. Specifically, it is requesting technologies that will:

- Allow for the recognition and understanding of the complete set of gestures used to guide manned aircraft during carrier deck operations;
- Accomplish this recognition in the same duration that is required for guiding manned aircraft
- Require only minimal additional devices to be used by the individuals making the gestures
- Demonstrate initial accuracy of at least 80%
- Have the ability to increase accuracy rates through learning
- Have the potential to learn new gestures

PHASE I: Required Phase I deliverables will include a feasibility study for a Natural Dialogue – based Gesture Recognition for Unmanned Aerial System Carrier Deck Operations that can provide a simple, easy to use ability for guiding UAS on a carrier flight deck without negatively impacting sortie rate. Included in this study will be an initial concept design, as well as a detailed outline of success criteria that address the requirements listed in the topic description. A final report will be generated, including system performance metrics and plans for Phase II. Phase II plans should include key component technological milestones and plans for incremental and final test and evaluation. Phase 1 should also include the processing and submission of all required human subjects use protocols should these be required. Due to the long review times involved, human subjects research is strongly discouraged during Phase 1.

PHASE II: Required Phase II deliverables will include the construction, demonstration and validation of a prototype based on results from Phase I. All appropriate engineering testing will be performed, and a critical design review will be conducted to finalize the design. Additional deliverables will include: (1.) a working prototype of the system (2.) drawings and specification for its construction, and (3.) performance assessment based on tests conducted in one or more simulated and/or operational settings, in accordance with the success criteria developed in Phase I. Assessment should include measures of system performance as well as human factors/usability-like measures of user performance.

PHASE III DUAL USE APPLICATIONS: This technology will have broad application in commercial as well as military settings. The US Navy continues to aggressively pursue a carrier based UAS capability. The proposed technologies will provide a significant benefit in realizing this goal. Other services continue to develop ground based unmanned systems which, likewise, should benefit from replacing more traditional and cumbersome control interfaces with the natural interfaces proposed in this topic. Commercially, Unmanned Systems are finding increase use across a range of applications including crowd monitoring, border patrol and related activities. These applications require often times require a rapid response by a single responder. The proposed technologies in this topic will provide a much reduced technology footprint, thereby making single responder requirements more manageable.

REFERENCES:

1. Christian von Hardenberg and François Bérard, "Bare-hand human-computer interaction", ACM International Conference Proceeding Series; Vol. 15 archive Proceedings of the 2001 workshop on Perceptive user interfaces, Orlando, Florida, Pages: 1 - 8, 2001.

2. Koenig, A. D., Lee, J. J., Iseli, M. R., & Wainess, R. A. (2009). A conceptual framework for assessing performance in games and simulations. Proceedings of the Interservice/Industry Training, Simulation and Education Conference, Orlando, FL.

3. Boyce, S., & Pahl, C. (2007). Developing domain ontologies for course content. Educational Technology & Society, 10 (3), 275– 288.

4. Jokinen, K. & McTear, M. (2010). Spoken dialogue systems. Morgan & Claypool, San Rafael, CA

KEYWORDS: Unmanned Aerial Systems; Unmanned Systems; Natural Language; Ontology; Aircraft Carrier; Human Machine Interface; Gesture

OSD12-IA1 TITLE: <u>Cyber Evaluation and Testing Assessment Toolkit (CETAT)</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative tools and techniques that aid in a formalized, Cyber-based forensic evaluation and assessment of a System Under Test (SUT).

DESCRIPTION: Maintaining U.S. Air Force Command and Control (C2) core cyber capabilities has led to the increased necessity for high-fidelity security assessments of their software systems. The need to properly analyze the performance and efficacy of current and future information systems is leading to more frequent cyber-centric system testing exercises which can result in large, unmanageable datasets. This data must be evaluated with manual processes and system-level tools, often post-experimental run. Deriving accurate qualitative and quantitative measurements in real time and visualizing them to the system testers without affecting the actual testing harness or skewing the results will provide insight into the attack effects and system components being monitored. The ideal test output is an aggregated system view that will inform the level of composition “goodness” (e.g. toward a quantitatively-measurable certification and accreditation activity), regardless of intended domain, threat coverage or system-level implementation specifics.

To produce definable and repeatable performance metrics (e.g., time to detect, react, and recover from attack or failure) technologies are needed to aid in gauging attack success or failure interdependent of attacker privilege or level of authorization to the underlying system. This should help lead to a concrete measurement of the attack and attack effects based on a functional requirement to prove or disprove the basic claims of the system, while capturing system-level sustainability, any potential degradation of service, and likelihood of future attacks. Analysis of observed events across multiple client sessions and experimental runs requires correlation between multiple collection points, a framework that maps system events to policy definitions, and a dynamic measurement of a range of performance metrics and the expected symptoms of the classes of attacks being launched. A holistic visualization tool will capture the physical entities within the system, network links, available services and system processes along with a logical representation of the attacks and their associated payload with the intent of creating a “click and drag” function that could launch an attack from a pre-defined location at any specific time interval. This will also aid in security exercise planning activities and will give a before, during, and post exercise awareness of the attack effects that could be centrally aggregated and scraped for forensic inspection.

Conducting security tests for today's services-centric systems warrants experimental measurement at both the physical and logical levels to properly characterize the attack effects at the node, network, and application layers. Measurement of undue stress or potentially malicious activity (e.g., CPU overload, OS process failure, malicious database manipulation) should inform cyber testers of the survivability of the system and potential future design enhancements. Understanding and validating attacker intent through various logging checkpoints, primary and secondary policy enforcement decision points, and system monitoring services would help create a policy mapping between the symptoms of attack and the critical components of the system.

We seek to research and develop cyber testing and evaluation analysis tools that incorporate best practice concepts where services-based systems can be designed and evaluated for performance and behavior characteristics. Other desirable features of this toolkit might include the ability to dynamically capture the efficacy of information technology assets under test, run simulations over heterogeneous system models, generate reports supporting testing and certification activities, and perform change impact analysis on existing systems using the models that are specified for them.

PHASE I: Research and develop a framework that encompasses the tools and techniques for capturing, representing, and visualizing, the performance of a SUT with a dynamic combination of specific logging functionality, network and node behavior to aid in the security assessment of heterogeneous nodes and diverse network topologies with multiple attack profiles.

PHASE II: Develop, implement and validate a prototype system that leverages the capabilities of Phase I. The prototype should produce adequate representation of the factors in an attack; give proper coverage of the target environment and the functional goals for the assessment. Accuracy across multiple runs should yield a solution that can be replayed in real or near real-time to aid security members from multiple teams (i.e., Red/Blue/White) easing capture of the assessment of the security claims of the system and ensuring the safety of military operations.

PHASE III DUAL USE APPLICATIONS: The value of assessments of distributed systems helps assure critical mission technologies. A standardized form of automated evaluation of the critical components of a security assessment without conducting manual log and data gathering post-exercise will allow security assessment teams and system designers the capability to alter testing specifics based on a better, more focused representation of the state of the system during attack. This will allow members of the defense industry and the commercial domain to conduct a more thorough evaluation of their existing systems and will result in a visualized awareness regardless of the order of magnitude of the data to be interpreted. Focus on log interpretation and integration from disparate sources has the potential to become a central service in the civilian domain where a real-time situational awareness at the system level is mandatory.

REFERENCES:

1. Air Force Cyber Command Strategic Vision February 2008. Available online at: http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA479060

2. A Roadmap for Cybersecurity Research, November 2009. Available from Homeland Security at: http://www.cyber.st.dhs.gov/docs/DHS-Cybersecurity-Roadmap.pdf

3. Partha P., Schantz R., Webber F., "Survivability Metrics - A View from the Trenches," May 18, 2004. Online at: https://dist-systems.bbn.com/papers/2007/DSN-MC/DPASA_EXP_MetricsChallengeFinal_v1.pdf

4. CSIA IWG, Infosec Research Council Hard Problems List, January 26, 2006. Available online at: http://www.nitrd.gov/subcommittee/csia/IRC_CSIA_Maughan_012606.pdf

5. Haglich, Peter, Grimshaw, Robert, Wilder, Steven, Nodine, Marian, and Lyles, Bryan. "Cyber Scientific Test Language", ISWC2011, Online at http://iswc2011.semanticweb.org/fileadmin/iswc/Papers/In-Use/70320097.pdf

KEYWORDS: Cyber, testing and evaluation, cyber-attack, red team, system under test

OSD12-IA2 TITLE: Multi-Abstractions System Reasoning Infrastructure toward Achieving Adaptive Computing Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a framework and infrastructure to enable system reasoning for supporting self-diagnostic, adaptive systems toward achieving missions.

DESCRIPTION: This SBIR topic solicits the design and development of framework, infrastructure, knowledge/model representation and methods for runtime reasoning of system's state, integrity and security of software systems, including operating system, applications and their components.

Large and complex systems of software, such as the ones used by DoD, are difficult to completely verify and secure. These systems are vulnerable to compromises which take advantage of the architecture, protocol and implementation weaknesses and flaws. As breaches and compromises have become a fact of computing life, it is important that our computing systems can adapt and operate effectively under such conditions. There is a need for a system which can continuously assess its own state/health, capabilities and limitations, and adapt to the situation, at cyber speed, toward maximizing the potential success of the missions. In the heart of such system there is a comprehensive and timely system reasoning infrastructure, a data-acquisition/event-recognition system and an intelligent system controller. Continuous reasoning and assessment prescribes the use of lightweight, programmable and selective data acquisition methods, which dynamically probes the system for various set of data points over time, under guidance of the system controller. If recorded, a log provided by the data acquisition system is contextual and sparse. The system controller uses system reasoning infrastructure to make sense of the probed data, compute the future event of interest and translate them into detailed description which can be used to set up the data acquisition system to catch future events of interest.

Current approach for analysis and diagnostic of a software system is based on ad-hoc rule/knowledge, provided by experienced practitioners. Such a static rule/knowledge based system cannot provide a comprehensive and up-to-date knowledge/model of the system. It is relatively inflexible and cannot account for unexpected conditions and new problems arising from removal, installation and changes of systems' components. Ad-hoc knowledge is also relatively slow to adapt, and requires time consuming manual analysis and knowledge update. Other form of diagnostic is the computer forensic or other type of memory-dump/system-image analysis. High frequency memory-dump based data acquisition can be prohibitive in term of load on the processor and data bus, and the forensic process is often heavy, requires manual intervention and will not be timely or responsive enough for runtime deployment.

This solicitation emphasizes on the design and development of the framework, infrastructure, and exploration for potential representation and methods for runtime (real-time or semi-real-time) reasoning of system's state of software systems, including operating system, applications and their components. The system reasoning infrastructure solicited in this topic needs to: 1) provide the appropriate abstraction for efficient reasoning, as well as providing bridging into fine grained semantic where an event or a sequent of events can be described and recognized/captured during runtime, 2) enable automated iterative analysis/diagnostic process, and predict/compute event(s) of interest based on its understanding of the systems' state, 3) accommodate the systems' configuration dynamic, as the components of the systems are removed, installed, or upgraded, over time, 4) and if necessary capable of analysis/diagnostic based on contextual and sparse log of dynamically (in term of instances and time) monitored events and parameters.

PHASE I: Design and develop a framework, infrastructure, and methods for runtime reasoning of system's state, integrity and security of software systems, including operating system, applications and their components. Develop a proof of concept implementation of the proposed design to demonstrate its required functionalities.

PHASE II: Develop and demonstrate a prototype framework, infrastructure, and methods for runtime reasoning, on a simple or pared-down operating system and a set of applications. Develop test cases and demonstrate that the system reasoning infrastructure satisfy all of the required functionalities.

PHASE III DUAL USE APPLICATION: The availability of runtime system reasoning infrastructure is an essential component for developing an adaptive and resilient software system. Other essential component for the system includes the programmable real-time monitoring sub-system, and the relatively straight forward system controller as the coordination agent between the monitoring and the reasoning sub-systems. The commercialization potential for the overall self-diagnostic adaptive system will be long term, as the overall system also relies on other components. This self-diagnostic adaptive system could be used in a broad range of environment requiring resilient computing infrastructure. It is applicable to both military and civilian enterprise applications. Besides its role in a self-diagnostic system, system reasoning may serve many other purposes, such as such as a reference for system verification, a model for system certification, etc. These applications of system reasoning may have a shorter-term commercialization horizon in the government and private sectors.

REFERENCES:
1. T. Garfinkel, M. Rosenblum, "A Virtual machine introspection based architecture for intrusion detection", Proceedings of Network & Distributed System Security Symposium 2003.

2. M. Sharif, W. Lee, W. Cui, and A. Lanzi, "Secure In-VM Monitoring Using Hardware Virtualization", Proceedings of the 16th ACM Conference on Computer and Communications Security (CCS), 9 November 2009

3. S. Sidiroglou, M. E. Locasto, S.W. Boyd, and A. D. Keromytis, "Building a reactive immune system for software services," in Proceedings of the annual conference on USENIX Annual Technical Conference, 2005, pp. 11–11.

4. H.E. Shrobe, et.al., AWDRAT: A cognitive middleware system for information survivability, AI Magazine, Vol.28, No. 3, Fall 2007.

KEYWORDS: Autonomic computing, adaptive system, resilient infrastructure, system reasoning, knowledge/model infrastructure, self-aware computing.

OSD12-IA3 TITLE: Metrics for Measuring Resilience and Criticality of Cyber Assets in Mission Success

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Developing cyber security metrics and algorithms for measuring resilience and mission criticality of cyber assets in wired and wireless networks.

DESCRIPTION: Cyber assets usually support missions with different priorities, and the objective and systematic measurement of their resilience and criticality may play a major role in mission success. One basic requirement for achieving mission success and mitigating the adverse impact of advanced threats is to measure the defense and resilience effectiveness of individual and collective cyber assets. Therefore, a comprehensive framework of metrics should be developed objectively and systematically for measuring the individual and collaborative resilience and mission criticality of cyber assets by taking mission assurance into consideration in wired and wireless networks. This framework should be modular in nature to account for the impact of different types of advanced threats and vulnerabilities, be reactive to network connectivity failures and new threats, and provide the commander with a status of metrics of interest on resilience and mission assurance. In a dynamic network environment, the number and importance of events often change, leading the criticality values of cyber assets to be changed as well. Dynamic reconfiguration of a network due to cyber attacks may also lead the values and functions of cyber assets to be changed over time. This implies that a solution to measuring mission criticality and resilience of cyber assets should assess dynamically the mission impact of cyber incidents, and associate accurately cyber assets with varying mission impacts. Indeed, when a mission involves with various types of cyber assets at different command levels, not only the cyber asset values but also the relative importance of commands should be taken into account to determine mission criticality of cyber assets. Consequently, mission criticality of cyber assets needs to be integrated with the resilience effectiveness measures, while computing how much cyber assets can contain adversaries, limit critical data exfiltration, recover from successful attacks, and maintain critical operations in the presence of cyber attacks.

PHASE I: This would develop/leverage a cyber measurement framework and set of metrics that are suitable for measuring resilience and mission criticality of cyber assets in a tactical environment. The investigator will develop algorithms to solve the aforementioned problem of measuring resilience and criticality of cyber assets by taking their individual and collective contribution to the overall mission success in a network environment where cyber assets belong to different command levels and/or multiple missions of different priorities. The Phase I should show the initial concept design of measurement framework as well as modeling key elements of resilience, asset criticality, and mission assurance for various scale of computer network defense service provider (CNDSP) operations. An integration design and experimental plan for cyber measurement framework is sought in this phase. This plan identifies necessary performance goals of interest in measuring resilience and criticality of cyber assets for mission success.

PHASE II: Execute the Phase I design plan. Develop, test, and validate implementations of top contending algorithms from Phase I. Show progress with initial performance goals and show appropriate milestone to extend these goals to a desirable military operational state. Demonstrate framework in a controlled laboratory environment at a minimum with potential for field demonstration in an existing CNDSP operational networking environment.

PHASE III DUAL USE APPLICATIONS:
- Military: These metrics, algorithms, and associated implementations can be transitioned to ARCYBER and other organizations for operational deployment. It is intended that a Phase III is encapsulated in a capstone demonstration at TRL that exceeds TRL 6.
- Commercial: The resulting metrics, algorithms, and associated implementations should have wide applicability to commercial network defense and network monitoring organizations or groups. The metrics and algorithms will have great potential use in the R&D community as a research tool.

REFERENCES:

1. J.R. Goodall, A. D'Amico, and J.K. Kopylec. CAMUS: Automatically Mapping Cyber Assets to Missions and Users. Military Communications Conference (MILCOM), Boston, 2009.

2. D.J. Bodeau, R. Graubart, and J. Fabius-Greene. Improving Cyber Security and Mission Assurance via Cyber Preparedness (Cyber Prep) Levels. IEEE Second Int. Conf. on Social Computing (SocialCom), 2010.

3. H. Cam. PeerShield: Determining Control and Resilience Criticality of Collaborative Cyber Assets in Networks. SPIE Defense, Security, and Sensing. 23-27 April 2012, Baltimore, MD, USA.

4. H. Okhravi, A. Johnson, J. Haines, T. Mayberry, and A. Chan. Dedicated vs. Distributed: A Study of Mission Survivability Metrics. MILCOM, Nov. 7-10, 2011.

5. A. Kim and M.H. Kang. Determining Asset Criticality for Cyber Defense. Technical Report, Naval Research Laboratory, September 23, 2011. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA550373

6. S. Musman, A. Temin, M, Tanner, D. Fox, B. Pridemore. Evaluating the Impact of Cyber Attacks on Missions. Case # 09-4577, MITRE Corp, 2010.

7. Measurement Frameworks and Metrics for Resilient Networks and Services. Technical Report, European Network and Information Security Agency, 2011.

8. Gabriel Jakobson, ``Mission Cyber Security Situation Assessment Using Impact Dependency Graphs," Proc. of IEEE the 14th Int. Conf. on Information Fusion (FUSION), 5-8 July 2011.

KEYWORDS: cyber security, metrics, resilience, criticality, mission assurance, cyber asset, networks

OSD12-IA4 TITLE: Novel Detection Mechanisms for Advanced Persistent Threat

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop novel algorithms, not signature based, for the detection of advanced persistent cyber threats with performance (true positive and false positive rates) acceptable for operational deployment.

DESCRIPTION: Existing CNDSP alert generation tools are based on the identification of known signatures and thus are not appropriate for the detection of advanced persistent threats in which the attacker explicitly avoids the use of known signatures. This leaves analysts with the time consuming process of analyzing raw data to identify such advanced persistent threats or leaves detection until after the attacker's compromise exhibits identifiable external behavior. While anomaly detection techniques have been examined by the research community, their true positive (TP) and false positive (FP) rates have typically left them undeployable. The need is to achieve TP and FP rates in non-signature based techniques that are deployable, i.e., high percent of TPs and very low number of FPs in relation to the number of TPs.

The proposer can consider the applicability of any other network or sensor data beyond the full network packets. This may include identification of additional sensor data needed by the algorithm, router logs, host profiles, etc. The proposer may assume that within a DoD network, the CNDSP team may collect and monitor any and all systems and network activity. The identification of what data is needed and how the data is to be analyzed for the identification of advanced persistent threats, with deployable TP and FP rates, would be a major accomplishment.

PHASE I: Develop approaches to solve the aforementioned problem of non-signature based anomaly detection with high TP and low FP rates on full packet analysis. The performer will develop detailed analysis of predicted performance that validates the TP and FP positive rates will be acceptable for deployment in large-scale CNDSP operations. The Phase I must show the initial concept design as well as modeling of key elements to support the aforementioned validation results. A design plan identifying the progression from theoretical approach to prototype and full development along with testing and validation protocols must be developed.

PHASE II: Execute the Phase I design plan. Develop, test, and validate implementations of top contending algorithms from Phase I. Show progress with initial performance goals and show appropriate milestone to extend these goals to a desirable CNDSP operational state. Demonstrate framework in a controlled laboratory environment at a minimum with potential for field demonstration in an existing CNDSP operational networking environment.

PHASE III DUAL USE APPLICATIONS:
- Military: It is intended that these algorithms and associated implementations be transitioned to CNDSP groups for operational deployment. It is intended that a Phase III is encapsulated in a capstone demonstration at TRL that exceeds TRL 6.
- Commercial: The resulting algorithms and associated implementations should have wide applicability to commercial network defense and network monitoring organizations or groups. The algorithms and performance metrics will have potential values to the R&D community as an indication of future research directions and the potential for solving the true challenge problems in the cybersecurity domain.

REFERENCES:
1. Stefan Axelsson. 2000. The base-rate fallacy and the difficulty of intrusion detection. ACM Trans. Inf. Syst. Secur. 3, 3 (August 2000), 186-205.

2. Animesh Patcha and Jung-Min Park. 2007. An overview of anomaly detection techniques: Existing solutions and latest technological trends. Comput. Netw. 51, 12 (August 2007), 3448-3470.

KEYWORDS: cyber defense, intrusion detection, anomaly detection

OSD12-IA5 TITLE: Advanced Indications and Warnings (I&W) via Threat Feed Aggregation

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an indications and warnings threat feed aggregation with weighted scoring to provide DoD with (near) real-time information on adversaries, to include forewarning of enemy actions or intentions.

DESCRIPTION: Indications and Warnings (I&W) are intelligence based activities that are intended to detect and report on time-sensitive intelligence information of foreign developments that could involve a threat to the United States military, political, or economical interests. Computer Network Defense Service Providers (CNDSPs) throughout the DoD are required to facilitate situational awareness of adversary cyber actions and intentions, but the capability is minimal. Situational awareness is imperative to providing effective computer network defense and securing the DoD Global Information Grid (GIG).

Establishment of an advanced I&W tool, which aggregates threats from already existing Government and commercial feeds, would be valuable in the DoD's cyber defense operations and overall mission. The capability should be designed to weight threats based on user selected categories, such as geographical location, type of threat, source, volume, association, etc. The threats themselves should be scored within the tool by severity level, in order to prioritize computer network defense response actions.

The challenge is to identify how to aggregate these multiple feeds and provide CNDSP analysts with a world view of ongoing threats and threat postures. The capability should allow analysts to identify threats observed elsewhere and identify their significance. This will allow analysts to pre-block and prioritize threats, based on changing world view. For instance, many threats seen on the west coast were first seen on the east coast; situational awareness must ensure that such seen threats cannot provide an ongoing threat as is currently the case.

PHASE I: Design an aggregated feed of known threats associated with ASN, CIDR blocks, and inheritance based on association and communication internal and external to the DoD GIG. Identify how to provide the needed situational awareness capability to CNDSP analysts, incorporating user defined weighting. Demonstrate the ability to provide a world view allowing for preemptive resolution and prioritization of threats. A design plan identifying the progression from theoretical approach to prototype and full development along with testing and validation protocols must be developed. This plan must include a plan for empirical evaluation and validation of the end product.

PHASE II: Implement the design from phase I. The capability should provide DoD with situational awareness of cyber threats and adversary behavior, in order to target cyber defense operations. Provide results of the evaluation and validation plan. Demonstrate the capability in an existing CNDSP operational networking environment.

PHASE III DUAL USE COMMERCIALIZATION:
-Military: Transition the capability to DoD CNDSP operations. Establish correlation of threat information to internal data, such as flow records, systems logs, firewall logs, etc., but information on threats found internally may not be released external to the DoD. The system may be setup as a "shadow" server in order to replicate threat data for correlation and trending based on internal data, while also ensuring the data stays internal to DoD. An Advanced I&W tool via. In addition, the data made available within the tool would support the DoD Continuous Monitoring and Risk Scoring (CMRS) initiative of dynamically monitoring risk across the GIG based on the security posture and emerging threats.
-Commercial: The desired situational awareness capability will have wide applicability to commercial network defense capability for the same reasons they are of value to DoD CNDSP. Operational systems may be located anywhere from a cloud-based login (external to the customer) or internal appliance which correlated threat information to internal customer data, such as flow records, system logs, firewalls logs, etc. The system would be employed in a similar fashion, but would not include any DoD-specific sensitive, for official use only, or classified data. If developed, the system could be leveraged by Managed Security Service Providers (MSSPs) in the computer network defense operations and specify targeted threats to customers.

REFERENCES:
1. http://www.aaai.org/Papers/Symposia/Fall/1998/FS-98-01/FS98-01-016.pdf

2. http://www.cisc.gc.ca/products_services/sentinel/document/early_warning_methodology_e.pdf

3. http://www.groupintel.com/wp-content/uploads/2008/04/isa2008_jps_novel_emerging.pdf

4. http://www.dtic.mil/cjcs_directives/cdata/unlimit/6510_01.pdf

5. http://www.dtic.mil/cjcs_directives/cdata/unlimit/m651001_v1.pdf

KEYWORDS: Network Defense, Cyber Defense, CNDSP, Indications and Warnings, Situational Awareness, Threat, Intelligence

OSD12-IA6 TITLE: BGP FLOWSPEC Enabling Dynamic Traffic Resilience

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a model of threat identification coupled with a means to redirect, reroute, or otherwise dynamically divert suspicious or malicious network activity to independent locations for investigation, in order to create a resilient network boundary capable of handling potentially widespread attack vectors.

DESCRIPTION: The current model implemented by Einstein for Trusted Internet Connections (TIC) services for the detection and mitigation of the Global Information Grid (GIG) enterprise is often inefficient and ineffective based on the volume of legitimate, suspicious, and known bad traffic. By creating a dynamic system of threat identification with an ability to control traffic and redirect as necessary to disparate locations, DoD will be capable of performing organized analysis of advanced persistent threats. Using a protocol such as BGP FLOWSPEC to allow internal analysis of both internal and external information to directly manipulate the path of network activity across a wide area network (WAN) will provide targeted analysis leveraging specific algorithms. The malicious traffic can be redirected to various locations for a combination of the following reasons: mitigating the adverse impact of advanced threats through agility (e.g., maneuvering to avoid attacks) and resilience (e.g., sustaining critical functions by deflecting, resisting, and absorbing attacks), conducting specialized analysis methods, and filtering out malicious traffic. The rulesets for controlling such redirection can be derived, based on the requirements of malicious traffic analysis, agility and resilience operations. The generic part of these rulesets can be crafted automatically and made available at all locations, while some additional customized rules can be designed having human-in-the-loop for specific needs of each location. Because each location may not be capable of conducting every type of malicious traffic analysis, the process of redirecting or diverting malicious traffic should be made intelligent enough to determine what type of malicious analysis is needed for any given malicious traffic. Hence, the capability to redirect advanced persistent threats to areas of excellence where advanced analysis and investigations may be performed would prove beneficial to USG and commercial organizations. Filtering of traffic is a protective and defensive measure, since it moves the malicious traffic to an identified location and also facilitates the analysis to aid in the advancement of detective measures. The operational capability can further define appropriate mitigation strategies such as redirect passive, redirect active, man-in-the-middle, or black hole.

PHASE I: Define a plan to develop a threat feed, internal traffic monitoring, redirecting malicious traffic for advanced threat analysis or implementing agility and resilience operations, mitigating adverse impact of severe threats, correlation and aggregation of different threat data, and algorithms to derive generic and customized rule sets for controlling redirection of malicious traffic. The customized ruleset will derive human response actions necessary to protect and response to adversary threats. The plan should include a connection of the threat feed systems with boundary network devices using BGP FLOWSPEC, which will determine the necessary human intervention versus automation. Also, define the optimal network architecture for maximum performance (division of threats, placement of filters, and redirects, etc.).

PHASE II: Implement Phase I plan. Develop a solution to covertly redirect the traffic, consisting of packet manipulation, and hop count using IPv6.

PHASE III DUAL USE APPLICATIONS
- Military: With a military implementation, details of the employment of BGP FLOWSPEC enabling traffic resilience will be sensitive to DoD. A similar architecture and capability may be implemented and designed for the requirements of DoD to provide the data in the appropriate places to effectively and efficiently analyze advance persistent threats and other adversarial activity.

- Commercial: The system could be employed to route traffic for analysis to commercial locations interested in further analyzing threats posing their organization, which would be beneficial in prioritizing defense mechanisms and responses to the activity. The solution would be beneficial to any commercial ISP or security service providers responsible for computer network defense operations.

REFERENCES:
1. http://www.gao.gov/new.items/d10237.pdf

2. http://www.whitehouse.gov/cybersecurity/comprehensive-national-cybersecurity-initiative

3. http://tools.ietf.org/html/rfc5575

4. http://tools.ietf.org/html/draft-ietf-idr-flow-spec-05

KEYWORDS: network resiliency, cyber defense, BGP FLOWSPEC, threat, traffic redirection

OSD12-LD1 TITLE: Autonomous Sensing and Deciding Framework Processor

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: Develop an innovative cognitive knowledge-aided information processing technique to take very large intelligence data streams over wide areas and autonomously highlight areas of interest for the image analyst without a priori knowledge of the area and/or location of targets of high interest.

DESCRIPTION: To meet the Department of Defense's need of advancing surveillance and reconnaissance for predictive intelligence, there has been a trend towards increasing the capability of data collection devices to deliver high resolution data points over long periods of time. Rapid advances in wide-area surveillance technologies result in exponential growth in data covering hundreds of square kilometer areas. Significant improvements in computational throughput from digital signal processors, such as the Field Programmable Gate Array (FPGA) and the General Purpose Graphics Processing Unit (GPGPU), have resulted in the processed data getting to the image analysts in real-time. However, this exponential growth in data volume means that human operators must very quickly make informed decisions on sub-meter resolution products covering hundreds of square kilometers of area. Development of autonomous information processing and cognitive knowledge-aided processing frameworks designed to do the following will greatly aid image analysts:
1. Increase situational awareness of the human operator
2. Reduce the manpower necessary for imagery scanning
3. Assist and enable decision makers responsible for resource allocation decisions that must be informed in real-time by the incoming data stream

Future airborne sensor systems that collect data will be able to be information processing centers as well. For example, one such system will be capable of dual-band (UHF and X-Band) synthetic aperture radar (SAR) that will be used for persistent surveillance of an urban area 10 km x 10 km with 1 ft resolution at X-Band and fully-polarimetric 1m resolution at UHF in the nominal operating mode. The radar is software configurable and can easily be switched to one of its many other operating modes. Image analysts can be easily overwhelmed with the gigabytes/sec data stream. The research required for this effort will be to develop an intelligent and autonomous method to use the information from the data products for finding areas of interest to focus the human operator's attention. These areas of interests will be presented to the human operators for threat assessment. The human operator may decide that collecting data in a different operating mode will better illuminate targets in the areas of interest. The sensor system can then be easily re-configured for that purpose and will provide better data for evaluation by the processor and human operator.

PHASE I: To investigate methods of using SAR information data products (imagery, GMTI data, change detection, etc.) as inputs and building an autonomous sensing and deciding framework to highlight areas of interest for the human analyst. Phase I will research technologies and develop design concepts for a novel and feasible approach that focuses the attention of the analyst. More specifically, we are looking for scalable models and algorithms that can achieve real-time performance of one SAR frame per second. The targeted SAR frame size is 20,000-by-20,000 pixels (12-bit binary data per pixel) with resolution of one foot. The targeted GMTI data contains a list of 10,000 moving objects, with information of position, velocities and radar cross-section features. The approach must also take into account of geographic information such as roads, buildings, landmarks, traffic signs and signals. With above-specified inputs, the proposed method should be able to provide quantitative measures (based on a knowledge-base) of the "normalcy" of all the events happening in real-time and provide the analyst a prioritized list of areas-of-interest. For example the "normalcy" of an event can be defined as the probabilistic measure of the existence of an object at a certain location, and/or its moving behavior (across consecutive frames), and/or coexistence of multiple objects, and/or relative behavior of multiple objects. Technologies of interest may include knowledge base format and storage, supervised and unsupervised learning, knowledge base retrieval, and quantitative representation of objects behaviors over time.

PHASE II: To develop and demonstrate a working prototype of an autonomous sensing, information processing and deciding framework that can run in real time using real time data supplied by the government.

PHASE III DUAL USE COMMERCIALIZATION: These techniques can be used in automated inspection or machine vision, e.g., detecting manufacturing defects, or video surveillance and also to monitor any sort of repeat remote sensing imagery (e.g., LANDSAT, IKONOS, etc.) to detect development changes for map updates.

REFERENCES:

1. Q. Wu, P. Mukre, R. Linderman, T. Renz, D. Burns, M. Moore, Q. Qiu, “Performance Optimization for Pattern Recognition using Associative Neural Memory,” 2008 IEEE International Conference on Multimedia & Expo, Hannover, Germany, 23-26 June 2008.

2. H. Motoda and K. Yoshida, “Machine learning techniques to make computers easier to use,” Proceedings of the Fifteenth International Joint Conference on Artificial Intelligence, 1997.

3. K. E. Dungan, L. C. Potter, J. Blackaby, and J. Nehrbass, “Discrimination of Civilian Vehicles using Wide-angle SAR,” Algorithms for Synthetic Aperture Radar Imagery XV, Proc. SPIE, E. G. Zelnio and F. D. Garber, Eds., vol. 6970, 2008.

4. G. E. Newstadt, E. Zelnio, L. Gorham, and A. O. Hero III, "Detection/tracking of moving targets with synthetic aperture radars," E. G. Zelnio and F. D. Garber, Eds., vol. 7699, no. 1. SPIE, 2010.

KEYWORDS: autonomous sensing, wide area search, synthetic aperture radar

OSD12-LD2 TITLE: Fusing Uncertain and Heterogeneous Information – Making Sense of the Battlefield

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop mathematical foundations, algorithms and software to meaningfully combine heterogeneous stochastic information to deduce a realistic, accurate and mathematically-provable convergent model – that is – to create a mental picture of what is happening and likely to happen in the battle space environment.

DESCRIPTION: Nearly all national defense missions involve Decision Support Systems—systems that aim to decrease the cycle time from the gathering of data to some operational decision. Proliferation of sensors and large data sets are overwhelming analysts, as they lack the tools to efficiently process, store, analyze, and retrieve vast amounts of data. This SBIR topic area, Data-to-Decisions, seeks to develop an open-source architecture system that enables rapid integration of existing and future data exploitation tools to achieve a new paradigm in the management and analysis of data. The initiative is pursing technologies to aid in the development of analytic approaches and advanced user-interface techniques to result in libraries of analytic and user-interaction modules that can be repurposed across a number of joint missions. Data-to-Decisions will use a proven "build-test-build" process that improves technical components by providing real-world data sets to researchers with oversight from front-line operators. Promising research avenues include:

- enhanced images
- temporal, and text analytics
- better software architectures
- improved algorithms for data fusion
- improved understanding of user interactions

These efforts will reduce latency with higher probability of detections and fewer false alarm rates; increase situational understanding in operational missions and thus support more relevant and informed decisions; and enhance ability to navigate and find important relationships and targets in extremely large data sets. The major emphasis of this specific SBIR topic – deals with the fourth bullet – improved algorithms for data fusion.

This proposed work should advance theoretical foundations, models, and algorithms to support timely, robust, near-optimal decision making in highly complex, dynamic systems, operating in uncertain, resource-constrained environments with incomplete information against a competent thinking adversary.

The evolving field of decision sciences involves numerous research disciplines: mathematics, operations research, statistics, industrial engineering, social, economic, psychological and cognitive sciences and others. Most importantly, these disciplines – to fully support operational decision making – must integrate and unify research effort. Currently, these research results are not sufficiently robust, nor adequately integrated to meet the needs in making complex decisions in an operational environment.

This research initiative will focus on integration of heterogeneous information to improve situational awareness and decision making, taking into account associated risks. This research emphasizes the dynamical, stochastic nature of information flow and the interaction between information processing and the commander's cognitive and decision making process. Integrated robust, responsive, dynamical system models of information across multiple operational networks (both human and automated) must be developed to appropriately utilize all information.

PHASE I: In phase I, a complete description of a robust decision support tool will be developed, including development of scientific underpinnings to adequately model and fuse complex information into a unified whole. Inference models should be developed describing sensor information flow, both physics-based sensors and human systems based data. Model should address characterizing temporal aspects of data, including non-data characteristics, historical-based patterns. Representative scenarios of realistic command-level operations and message traffic to reveal dimensions and factor structures should be developed, based on cognitive task analysis, which conceptualizes tasks of the mission space, the interrelationship of information in time and space and how these tasks will be cyclically impacted by his application of assets in this space.

Advanced numerical inference modeling and optimization (stochastic) techniques should be developed. These techniques should be capable of utilizing all information by appropriately integrating this information into mathematically-based inference models. Risk must be addressed, specifically involving alternative planning scenarios. Conditional value at risk, a stochastic measure of risk, has proven to be a mathematically sound principle which has been applied in the investment community. This methodology should be applied to military decision making.

Demonstration software will be produced in Phase I for both the inference models, numerical optimization, as described above.

PHASE II: In phase II, developments in phase I will be extended to add more capabilities. Adding social factors to the mix of other factors is very critical. Social/cultural properties of information content/ flow should be identified and incorporated to account for the effects of these properties in processing data to account for accuracy, temporal aspects, and completeness. Biases and skewed properties should be accurately modeled using alternative distributions. Latency must be taken into account in how cultural/social properties affect timing. These dimensions will be added to the developments of phase I, including incorporation into the demonstration software.

The demonstration software should be extended and integrated into a functioning test bed, where tests are conducted using realistic scenarios. From multiple tests, summary information on the advantages, qualitative and quantitative, of using an information network-based flow approach to model and build an effective, efficient tool for command-level decision support should be provided. Evaluation should be based on realistic scenarios that include variable events and that also include at least a slice of the continuum of the tactical network. Recommendations for incorporation of decision support tools, alternative organizational design, deployment of specific staff resources, and other potential improvements.

PHASE III DUAL-USE COMMERCIALIZATION: Ownership of intellectual property is not intended as part of this SBIR. Rather, the more innovative approach of open-source architecture will better serve small business entrepreneurs. The output of these efforts in phase III will yield components which are easily assembled and configurable for operational users to customize and adapt to rapidly changing scenarios. As a result, innovation will continue and evolve, producing small business opportunities over the next decade.

REFERENCES:

1. Mathematical Modeling and Optimal Control of Battlefield Information Flow, D. Phillips, Naval Postgraduate School, June 2008, PhD Dissertation.

2. The Role of Information in Multi-period Risk Measurement, G. Ch. Pflug,W. Romisch, Department of Statistics and Decision Support Systems, University of Vienna, 1090 Vienna, Austria. 2009

3. Rockafellar R.T. and S. Uryasev (2001): Conditional Value-at-Risk for General Loss Distributions. Research Report 2001-5. ISE Dept., University of Florida, April 2001.

4. The Skill Element in Decision Making under Uncertainty: Control or Competence? A. Goodie, D. Young, Judgment and Decision Making, Vol. 2, No. 3, June 2007

KEYWORDS: information fusion, inference modeling, optimization, stochastic, conditional value at risk

OSD12-LD3 TITLE: Data to Decisions, Information Systems Technology

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: Design and implement a cloud enabled system that allows sensors to be dynamically tasked based on the latest status of information requirements and on-line analytic predictive processing. The system would enable an automated sensor planner to know at all times what to look for and where to look.

DESCRIPTION: Compounding the large data problem faced by DoD are poorly informed sensors that can continue to add large streams of data to a data warehouse that is neither responsive to an information need or incorrectly placed relative to a collection opportunity. Sensor planning is often done well in advance of collection via many sensor or sensor type independent planning processes. A good planner may align collection with information requirements when the plan is authored, but maintaining alignment with changing mission requirements and/or knowledge levels is not feasible today. The use of advanced predictive tools is one way to more efficiently and effectively translate information requirements into detailed collection plans but today predictive tools often prefer to operate off-line in a batch mode. Mining a data cloud for sensor reported data could be an effective way to prevent one sensor from trying to gather information that has already become known or is no longer valued provided this can be accomplished on diverse and distributed data in real time. Similarly widgets could be used to track all published information requirements across a distributed battlespace. The direction of the services is to utilize cloud architectures to store what is known and these same architectures can be used to store what is needed to be known. Predictive analysis engines, running as real time map reduce jobs, could be used to inform sensors where to look and discovered information and discovered information needs could be used to further optimize their activity.

The goal of this topic is to enable sensors to stream information vice raw data into the cloud through intelligent sensing. An initial product can consider a handful of information needs, a modest sized data cloud and a handful of distributed processors each supporting a handful of sensors. IMINT and unstructured reporting should be among the sensor considered. The matured system must be able to produce sensor tasking in real time to hundreds of sensors, informed by what needs to be known, what has become known and how collection can be optimized to meet an information need. For the overall system, the Hadoop framework should be considered. The specific challenges of this topic include: 1) Maturing predictive algorithms that can run model updates in real time as a distributed application using data discovered from a data cloud 2) Maturing a set of data miners that can discover information needs and route them to the processor that is responsible to tasking the most relevant sensor 3) Maturing a collection of widgets that constantly look inside a data cloud to see if what was needed to be known is now known or if new information requirements have been published. 4) Development of a real time sensor manager that tasks sensors based on accurate knowledge of the highest unfilled information requirements in the most efficient and effective manner possible.

Research in the areas of mathematics, computer science, information theory, cloud computing, control theory, network theory and distributed sensor resource management as well as multidisciplinary areas that may prove promising are of interest. In addition to the application of research methods and approaches, it is important to evaluate the impact of these efforts areas with regards to the way they change how tasking is designed and data is collected to positively impact decisions.

The OSD is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are encouraged.

PHASE I: Complete a plan and detailed approach for populating an architecture that supports in real time the information needs of a sensor manager. Retire risk associated with on-line predictive analysis and real-time discovery of targeted information in a cloud. Identify the critical technology issues that must be overcome to achieve success. Technical work should focus on the reduction of the identified key risk areas to a phase II prototype. For a bounded set of information needs and sensors populated within a modest sized cloud architecture, demonstrate that phase 1 risk reduction work has shown that a full implementation of the approach is technically tractable. Prepare a revised research plan for Phase 2 that addresses critical issues.

PHASE II: Produce a prototype system that is capable of distributed sensor management in a cloud environment. The prototype system should continuously assess what needs to be known, what is already known and what predictive models are saying is the best way to collect the balance. The system should run across a distributed architecture, enabled by map reduce jobs and ozone widgets, The system should provide in real time a computed sensor field efficiency index, a measure of how well current sensor tasking is expected to be against unknown information needs. The prototype should enable a demonstration of the capability to be conducted using relevant sensor models, data streams and information requirements, some of which may be classified. The prototype should be capable of operating in a real time mode. The prototype should be relevant to both DoD and commercial homeland defense and security use cases.

PHASE III DUAL-USE COMMERCIALIZATION: Produce a system capable of deployment in an operational setting. The work should focus on a specific user environment intended for product transition. Test the system in an operational setting as a component within a service cloud architecture. The performer should work towards a transition to program of record, a military organization and a commercial product. The system should adhere to open standards and be delivered with full Government purpose rights.

REFERENCES:
1. Apache Software Foundation. ActiveMQ. 9/22/2010 http://activemq.apache.org

2. Apache Hadoop: http://hadoop.apache.org/

3. Cloud computing, wikipedia 2011, http://en.wikipedia.org/wiki/Cloud_computing

4. Real time predictive analysis: http://blog.thoughtcorp.com/2011/02/03/real-time-predictive-analytics/

5. Smarter Decisions Through Predictive Analysis: http://www.ayata.com/pdfs/Predictive-Analytics-In-Clean-Energy.pdf

KEYWORDS: sensor planning, on-line analytic processing, cloud computing, predictive analysis, information requirements, data mining, map reduce

OSD12-LD4 TITLE: Intuitive Information Fusion and Visualization

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Establish intuitive decision-centric approaches to simplify complex information fusion (IF) techniques for rapid collection, processing, and understanding of large stores of data.

DESCRIPTION: The Data to Decisions (D2D) initiative, noted as one of the top seven Science and Technology challenges for the US Department of Defense, has been largely defined and implemented as an information fusion (IF) problem. As [1] notes, this community grew out of the sensor fusion effort that has fusion techniques that don't scale with increasing data sizes. As the D2D program elements have developed to address the identified challenges of data size, processing, and decision support, the decision-theoretic foundation of IF has not changed. IF systems continue to presume a rational decision model for users, when cognitive and social scientists have shown the predominance of models such as naturalistic or intuitive decision making, sensemaking, etc. Researchers are exploring the cognitive connection in IF. The Cognitive-Observe-Orient-Decide-Act (C-OODA) loop is discussed by [2], and [3] suggest that cognitive methodologies are needed to understand how individuals use IF systems and their respective decision making processes. This thinking is further extended by [4] to explore how an IF system would be designed if it were based on a sensemaking (rather than a rational) model of decision making.

The challenges recognized by D2D essentially capture the reality that IF systems are not able to handle the current challenges facing human decision makers. Two related developments have occurred within the past decade of asymmetric warfare. Central among these is the dynamic nature of asymmetric warfare, for which researchers have devoted great attention. The Counter-Insurgency (COIN) doctrine [5] and the DOD Human Social Cultural Behavioral (HSCB) Modeling Program [6] have identified the non-lethal and non-kinetic factors that must be addressed for current and future military operations. On a parallel path, the advances in information technology and the growth of social media applications on the global internet have added to the ways in which people share information and exert influence for personal and business purposes. The Arab Spring demonstrations were a lesson in how open source technology can be used for political and social purposes [7]. These demonstrations may also have created a paradoxical situation that could signal a new era in IF for decision support. If the online and open source media provides a relevant source of data that includes some meaningful meta-data, perhaps a new variety of IF system can be imagined; and one that provides functional activities that can overcome the biases present in each human decision maker. Examples of biases include values and beliefs, world reference models, preconceptions and objectives, previous experience, and cultural traditions [4]. Addressing confirmation bias and aligning with cognitive strengths of individuals are additional goals.

We seek novel exploitation of intuitive decision-theoretic concepts as they can be applied to the development of an information fusion system that can provide information in a way consistent with the underlying construct of how people perceive and react to information in time-constrained and complex situations.

Challenges in this topic include selection of a decision foundation, designing an approach to information integration and presentation, and designing a concept for visualization of information that is consistent with the underlying theory of how people perceive and use information in cognitively constrained situations. We seek innovative and novel approaches to what has become in the military a highly engineered system that does not mimic the decision processes followed by human users. We are interested in defining critical points in a decision process that can be re-engineered with respect to IF to improve the decision maker's understanding of the environment. Challenges in the fusion process should include new approaches to dealing with uncertainty and unknown factors in the environment and hypothesis testing. Throughout the development process, performance measures should be developed.

PHASE I: Conceptualize and define an innovative approach to information fusion that is structured upon an intuitive theory of decision making. Identify and define the theoretical approach and provide examples of how a fusion architecture would be composed to collect, integrate, and present information in ways that are consistent with the theoretical approach to human understanding of this information. At the conclusion of Phase I, produce a conceptual design and breadboard of a small fusion architecture that clearly reflects novel instantiations of the supporting decision theory. Phase II plans should also be provided, to include key component technological milestones and plans for testing and validation.

PHASE II: Develop, demonstrate, and validate a prototype system based on the preliminary design from Phase I. All appropriate engineering testing will be performed, and a critical design review will be performed to finalize the design. Phase II deliverables will include a working prototype of the system, specification for its development, and a demonstration of the decision-centric fusion tool.

PHASE III DUAL USE COMMERCIALIZATION: This technology will have broad application in military, government, and commercial settings. Within the military and government, there is an increasing emphasis on information fusion technologies that aid decision makers responding to foreign nations that are potentially hostile to the US and Coalition interests. Developing models and tools that can rapidly integrate and present information in ways that compliment a user's decision making process will be a powerful addition to strategic, operational, and tactical decision making. The proposed effort will enable the delivery of more informed courses of action supported by tractable information sources.

REFERENCES:
1. Lambert, D. A., "Grand Challenges of Information Fusion." ISIF, (2003). Available on the Internet at: http://ftp.isif.org/fusion/proceedings/fusion03CD/special/s96.pdf

2. Blasch, E.P.; Breton, R.; Valin, P.; Bosse, E.; "User information fusion decision making analysis with the C-OODA model," Information Fusion (FUSION), July 2011.

3. Nilsson, M.; Ziemke, T.; "Information fusion: a decision support perspective," Information Fusion, 2007 10th International Conference on, 1-8, July 2007.

4. van Laere, J., Nilsson, M., Ziemke, T. "Implications of a Weickian perspective on decision-making for information fusion research and practice," Information Fusion, 2007 10th International Conference, pp.1-8, 9-12 July 2007.

5. Department of the Army. (2006) Counterinsurgency. Field Manual No. 3-24. Washington, D.C.: Department of the Army.

6. Schmorrow, D. (2011). Sociocultural Behavior Research And Engineering in the Department of Defense Context. Washington, D.C.: Office of Secretary of Defense.

7. Shillinger, R., "Social media and the Arab Spring: What have we learned?" The Huffington Post, 20 September 2011, http://www.huffingtonpost.com/raymond-schillinger/arab-spring-social-media_b_970165.html; http://www.huffingtonpost.com/ (2011).

KEYWORDS: information fusion, perceptual sensing, decision strategies, decision making theories

OSD12-LD5 TITLE: Extracting Event Attributes from Unstructured Textual Data for Persistent Situational Awareness

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research and develop automated capabilities to extract events with modality, polarity, genericity, and tense attributes from unstructured textual data sources, such as news articles or Human Intelligence (HUMINT) reports, to enable persistent Situational Awareness.

DESCRIPTION: Intelligence analysts need the ability to rapidly monitor and analyze event information in large volumes of unstructured textual data, such as news articles or HUMINT reports, in order to achieve and maintain persistent Situational Awareness (SA). For example, the ability to stay apprised of events that have already occurred, as well as events that are threatened or planned, would be a valuable contribution to an analyst's SA. The problem is that the amount of unstructured textual data available is well beyond what can be manually read and processed in the time available. A capability enabling analysts to rapidly extract event information from large volumes of unstructured text and store it in a structured form, such as a database, is needed to improve an analysts' ability to maintain persistent SA.

The goal of this topic is to advance the state-of-the art for extracting events with their attributes of modality, polarity, genericity, and tense from large volumes of unstructured text. Modality of an event indicates if the event was a real occurrence. Examples of event modality include asserted, i.e. "The bomb exploded on Sunday;" believed, i.e. "It is rumored he will be sentenced;" hypothetical, i.e. "If he were arrested, he would be convicted of murder;" and threatened, i.e. "He threatened to attack the country." Event polarity indicates whether the event actually occurred. For example, "The city was not attacked" is an event with negative polarity, and "The attack occurred on Sunday" is an event with positive polarity. Genericity indicates whether an event is specific, i.e. "The city was attacked on Saturday", or generic, i.e. "They specialize in transporting weapons." Tense indicates whether an event occurred in the past, is occurring in the present, or will occur in the future. Secondary challenges include, but may not be limited to, rapid customization to different sources/styles/formats of textual data, and rapid customization to various domains (areas of interest). While addressing other technology gaps that would contribute to the capability would be useful, it is optional since it should not happen at the expense of addressing the primary research challenge of extracting event attributes.

Capturing events with attribute information and storing them in a structured form would enable more efficient exploitation of event information, as well as the use of automated analysis and visualization tools. Most event extraction systems extract event mentions and arguments, but do not extract the modality, polarity, genericity, and tense attributes of the event. Automatically extracting event attribute information and storing it in a structured form would enable more efficient search techniques, such as allowing an analyst to search for threatened or planned events, and support rapidly identifying relevant information. This capability would also enable analysts to leverage information from large collections of textual documents, and as well as save the information for use by other analysts and use in the future, which would support establishing and maintaining SA.

PHASE I: Research and develop techniques for extracting events with modality, polarity, genericity, and tense attributes. Experiment with, and assess the feasibility of different approaches, with the end goal of achieving high accuracy extraction. Based on these results, develop an initial design for a prototype to extract events with attributes from unstructured text. Finally, develop a feasibility demonstration that substantiates the design and chosen approach.

PHASE II: Perform in-depth research and develop a full scale prototype to extract events and attributes from large volumes of unstructured text. The government's intent is to achieve an improvement in the state-of-the art and to identify a user with real data to support this work. Demonstrate the effectiveness of the capability for supporting persistent Situational Awareness by addressing a comprehensive set of event types and including the attributes of modality, polarity, genericity, and tense. Evaluate and substantiate the performance of the prototype by obtaining measures of precision, recall and F-measure against a test data set.

PHASE III DUAL-USE COMMERCIALIZATION: The research and development of this technology will improve the state-of-the-art of event-attribute extraction. The research has a wide range of potential applications within government and commercial markets. Essentially, any application that deals with information overload and the monitoring of events can be assisted by the developed capability.

Military Application: Intelligence analysts would benefit from a capability enabling rapid discovery of event information relevant to their analysis tasks within large volumes of text.
Commercial Application: Law Enforcement, Homeland Security, financial and medical markets could use this capability to rapidly identify events of interest, such as planned or threatened events.

This phase will explore, pursue and market paths for military and commercial applications of the developed technology. This phase will also focus on inserting and evaluating the performance of the developed technology in operational environments.

REFERENCES:
1. “Automatic Content Extraction (ACE) English Annotation Guidelines for Events.” Version 5.4.1 2005.07.01. http://projects.ldc.upenn.edu/ace/docs/English-Events-Guidelines_v5.4.3.pdf, accessed 20 March 2012.

2. Ahn, David. “The Stages of Event Extraction.” Proceedings of the Workshop on Annotation and Reasoning about Time and Events, pages 1-8, Sydney, July 2006. http://acl.ldc.upenn.edu/W/W06/W06-0901.pdf, accessed 20 March 2012.

3. UzZaman, Naushad and James F. Allen. “TRIPS and TRIOS System for TempEval-2: Extracting Temporal Information from Text.” Proceedings of the 5th International Workshop on Semantic Evaluation, 2010. http://cs.rochester.edu/users/grads/naushad/paper/TempEval2010-TRIPS-TRIOS-UzZaman-Allen.pdf, accessed 21 March 2012.

KEYWORDS: event extraction, event attribute extraction, modality, polarity, genericity, tense

OSD12-LD6 TITLE: Text Analytics from Audio

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Design and implement system that combines audio transcription and translation tools with natural language processing capabilities that enable actionable information to be automatically extracted from audio files.

DESCRIPTION: Text analytics is a growing field and central to the war on insurgents. While advances have been made in the development of tools that can extract entities, associations, concepts (word frames) and themes from English written text documents, additional work is required to show that actionable intelligence can be automatically extracted from foreign language audio. When transcription and translation tools are placed in front of natural language analytics the task of automated understanding is challenged by word error rates. Given a goal of an acceptable level of machine characterization of the content of an audio file, a future system must track error rates after every step (translation, transcription, natural language processing including entity and association extraction as well as concept and theme recognition), make corrections and track confidence levels. Systematic errors can be corrected for using replacement lookup tables. Random errors may be corrected through some sort of word voting scheme. For this topic, offerors may work with audio files spoken in one foreign language. Phase 1 performers may work with open source data. The specific challenges of this topic include: 1) Improving the key word error rates of transcription services 2) Improving the key word error rates of translation services 3) Improving the robustness to word error rates to entity and association extraction 4) Improving the uncertainty calculation associated with the output of a natural language engine that starts with audio 5) Demonstrating concept and theme identification can be robust to word error rates.

Research in the areas of linguistics, natural language processing, mathematics, statistics, computational data analysis and visualization, computational sciences and computer science are of interest. In addition to the application of research methods and approaches, it is important to evaluate the impact of these efforts areas with regards to the way they change how data is collected, analyzed and assessed to meet a prescribed time for operational necessity and efficiency. It is of value to use open standards to reduce costs.

The OSD is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are encouraged.

PHASE I: Complete a plan and detailed approach for developing an automated system for characterizing the information content of a foreign language audio file. Identify the critical technology issues that must be overcome to achieve success. Technical work should focus on the reduction of key risk areas. For a constrained set of languages (one is acceptable) demonstrate that phase 1 risk reduction work has shown that a full implementation of the approach is technically tractable. The matured system should show that natural language applications such as entity and association extraction, concept (word frame) identification and theme recognition can follow transcription and translation applications. Prepare a revised research plan for Phase II that addresses critical issues.

PHASE II: Produce a prototype system that is capable of entity and association extraction, concept (word frame) identification and theme recognition at acceptable error rates when processing audio files. Produce a prototype processing service that can operate in a cloud architecture to enable a high throughput of data. The prototype should enable a demonstration of the capability to be conducted using relevant data sources, some of which may be classified. The prototype should be capable of operating in a real time mode. Identify appropriate test performance dependent variables and make trade-off studies. The prototype should be relevant to both DoD and commercial use cases.

PHASE III DUAL-USE COMMERCIALIZATION: Produce a system capable of deployment in an operational setting. The work should focus on a specific user environment intended for product transition. Test the system in an operational setting in a stand-alone mode or as a map reduce job in a cloud architecture. The work should work towards a transition to program of record, military organization or commercial product. The system should adhere to open standards and open source software wherever feasible.

REFERENCES:
1. Apache Software Foundation. ActiveMQ. 9/22/2010 http://activemq.apache.org

2. Apache Hadoop: http://hadoop.apache.org/

3. FrameNet: http://framenet.icsi.berkeley.edu/

4. A Post-Processing System To Yield Reduced Word Error Rates:
http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.23.5624

5. Audio Filers: http://en.wikipedia.org/wiki/Audio_filter

KEYWORDS: audio processing, natural language processing, translation, transcription, word error rates, cloud computing, word gazetteers, word frames, map reduce

OSD12-LD7 TITLE: <u>Tactical Information Management</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Distributed warfighters operating small handheld tactical communications and computing devices are experiencing increased workloads, decreasing the potential benefit of using those devices. The operator needs to receive relevant information tailored to the specific mission requirements with minimal input to the device. The objective is to develop automated tools that can help determine the value of the information to the user and send only needed information when it is needed.

DESCRIPTION: The amount of data streaming into tactical systems is overwhelming the operators trying to make sense of unfolding situations. There are often multiple sources reporting on the same event that is of critical interest to the operator. The operators need ready access to the most pertinent and valuable information for their given situation. Current systems do not assign relative values to the incoming data so that the systems can prioritize or highlight the presentation of the information to the operator. It may even be the case that the highest value information is the result of a combination of two or more reports that compliment and/or confirm an event. ONR is seeking a framework for managing information with emphasis on the relative value of that information for a wide range of operations. The anticipated employment of this framework would be within a combat operations center with secure connectivity to higher and adjacent commands. Additionally, this framework needs to be extensible to support distributed small units operating over intermittent, low throughput tactical wireless networks.

Solutions that can automate common tasks and information requirements for the small unit leader, and be delivered over tactical communications in a mobile ad-hoc networking (MANET) environment. Potential solutions will be used in foot mobile operations and will need to work within a minimized size, weight and power (SWAP) environment.

PHASE I: Determine methodology for determining information value. Perform simulation and modeling to show how the proposed methodology will effectively increase the quality and usefulness of information provided. Develop plan for implementing the methodology in a practical system.

PHASE II: Develop and demonstrate the selected methodologies with contractor-supplied data sources. Further develop a decision support capability that can be further demonstrated to provide 90% correct information, within a useful time period, with only 10% of needed information missing compared to data processed by human experts.

PHASE III: DUAL USE COMMERCIALIZATION: Provide a TRL 7 decision support system integrated into a selected program of record. Demonstrate system on Government-provided data with the same correctness as shown in Phase II.

REFERENCES:
1. http://webhome.csc.uvic.ca/~onat/Briefs/workshop-CRD-Victoria-Bosse-2x.pdf

2. http://www.vistology.com/papers/1569352501.pdf

3. http://www.dodccrp.org/events/12th_ICCRTS/CD/html/presentations/188.pdf

KEYWORDS: Information value; decision support

OSD12-LD8 TITLE: Semantic Targeting for Open Source Intelligence Analysis

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Apply semantic targeting to large and complex, uncertain, contradictory and incomplete data sets to extract decision relevant intelligence information based on filtering by context and meaning.

DESCRIPTION: The 2012 National Security Strategy has indicated that “for the foreseeable future, the United States will continue to take an active approach to countering [threats] by monitoring the activities of non-state threats worldwide”. Groups and organizations are frequently informally structured, and operate as distributed entities on an ad hoc basis. Further, with ever increasing decentralization of decision-making enabled through ubiquitous electronic communication, there is a need to identify threats in large and complex, uncertain, contradictory and incomplete data sets available in the open source environment. The resulting flood of multi-sensor, multi-source data overwhelms analysts and operators because there is too much data. Information needs to be extracted based on its likely value for planning and intelligence needs. Semantic targeting may provide a vehicle to mathematically extract data more likely to be of value as information. Semantic targeting has been used in online advertising to identify high-value targets for product marketing programs. The approach leverages principles of the semantic web combined with behavioral targeting and contextual advertising. A similar approach could be applied to open source intelligence analysis where the challenge is dealing with deriving and/or detecting information intent and contextual uncertainty from large quantities of communication data.

The optimal data set might be one day of data collected at a Major Military Command for use in the Commander’s daily status brief. Unclassified data collected could include: multinational and NGO email, local news media publications and broadcasts, social media traffic and blogs, government publications and statements and general Internet traffic. Other available data sets of a similar nature would be public and government communication during Katrina or public and government communication during the events surrounding 9/11/2001. The employed search techniques would be modulated and informed by cognitive science-based algorithms that would prioritize, filter, fuse, interpret, and graphically display results for intelligence analyst review. Models of analyst-based behavioral inferencing, and trust would be incorporated into the algorithms. A possible approach would use two types of sorting and matching mechanisms: 1) Mathematically model analyst behavior in terms of how that analyst extracts intent and meaning from a corpus of ill-structured open source data; 2) Use semantic analysis of the data corpus to sort the data and to extract intent and meaning based on modeled analyst behaviors.

PHASE I: Proposals for Phase I will incorporate a literature search of semantic targeting research and applications in order to suggest a baseline for design and construction of a conceptual model. The proposed conceptual model will incorporate search techniques and supporting algorithms in a design that could be tested and validated with a corpus of data such as that generated during the Katrina or 9/11 incidents. Phase 1 must identify a proposed operational context, i.e., application, for developing and demonstrating the proposed model and identify data that would be used in validating the algorithms.

PHASE II: Develop and demonstrate a prototype instantiation of the conceptual model. Conduct test bed-based validation in an experimental or simulated environment. Initial demonstrations may be conducted using a notional scenario and synthetic data. However, evaluations with actual data must be conducted before the end of phase 2. Software documentation and guidelines for application must be included in the phase 2 report. A controlled yet realistic experiment must be conducted to quantify the anticipated improvement in intelligence analyst performance using any algorithms developed.

PHASE III DUAL-USE COMMERCIALIZATION: The developed prototype could be used in other military initiatives (concept engineering) or could be applied to business models (web-based or market-based) that require an assessment of product acceptance by the public or a selected corporate market area.

REFERENCES:
1. Action understanding as inverse planning. Baker, C. L., Saxe, R., & Tenenbaum, J. B. (2009). Cognition, 113, 329-349

2. Optimal predictions in everyday cognition. Griffiths, T. L. and Tenenbaum, J. B. (2006). Psychological Science 17(9), 767-773. Article in The Economist.

3. Intelligence Analysis: How to Think in Complex Environments Wayne Michael Hall, Gary Citrenbaum: Praeger Security International, 2010

4. "Semantic Web and Target-Centric Intelligence: Building Flexible Systems that Foster Collaboration": Aaron Manes, Jennifer Golbeck, James Hendler; available at profilesinterror.mindswap.org.MIND LAB at University of Maryland Institute for Advanced Computer Studies

5. Same world, different words: Augmenting sensor output through semantics: Anne-Laure Jousselme, Valentina Dragos, Anne-Claire Boury-Brisset and Patrick Maupin ieee:1-8 1 Jul 2011 in: Information Fusion (FUSION), 2011 Proceedings of the 14th International Conference

KEYWORDS: Semantic Targeting, Semantic Web, Behavioral Targeting